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ABSTRACT

The first phase of a projected research program aimed at examining children's ideas about body functioning, this study focuses on concepts of digestion, elimination of waste and assimilation of food held by children of different ages. (Subjects expressed these concepts both verbally and graphically). Possible cues to the influence of affect on these concepts are also explored. The sample consisted of 61 subjects: 20 kindergarteners, 20 third graders, and 21 seventh graders, with an equal number of boys and girls at each grade level except for the seventh grade, where there were 11 girls. Data were gathered in two interview sessions that usually took place in the same week. Measures administered in the first session included, in order, (1) an interview focused on the digestive system and its functions, (2) the Wechsler Preschool and Primary Scale of Intelligence or the Wechsler Intelligence Scale for Children, and (3) a drawing of the digestive process. Subjects were asked to draw a person at the end of the second session. Results are discussed which indicate that even the oldest children's understandings of the digestive-distributive-assimilative processes are limited. Research instruments used in the study are appended. (RH)

A DEVELOPMENTAL STUDY OF CONCEPTS OF BODY FUNCTIONING

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I. INTRODUCTION

Studies of cognitive development have, for the most part, been concerned with the learning and understanding of external phenomena, with children's ideas and ways of thinking about events that are directly observable. There have been comparatively few studies of children's concepts of internal processes, mental or physical. Fewer still have been concerned with concepts of the functioning of internal body systems.

Since internal body processes cannot be directly observed, children's ideas about the functioning of internal body systems may reveal different patterns of cognitive functioning than do their ideas about observable events. In addition, the workings of the body frequently arouse anxiety. As a result, affective elements are more likely to influence this realm of conceptual functioning and to generate a less purely rational mode of thinking. Thus, ideas about how the body functions constitute a promising arena for the study of cognitive-affective interaction.

The study constitutes the first phase of a projected research program aimed at examining children's ideas about body functioning. It focuses on concepts of digestion, elimination of waste and assimilation of food held by children of different ages as expressed both verbally and graphically, and explores possible cues to the influence of affect on these concepts.

We selected the digestive system as the internal body system for study because:

(1) Food and the intake and outgo processes associated with it are a significant part of everyone's experience from the earliest days of life.

(2) What is ingested and egested is concrete and perceptible.

(3) There are many intra-body sensory experiences connected with food (chewing, eating, drinking, vomiting, as well as internal sensations of hunger, thirst, urge to eliminate waste, gas, and sensations resulting from malfunctioning of the system).

(4) Some of the effects of eating can be perceived. Thus, children are

more aware of the processes associated with eating and excreting than they are of breathing, thinking, the circulation of blood, or any activities associated with other body systems.

We would expect concepts of the digestive system to be especially influenced by feelings because eating and elimination are so tied in with the child's feelings of being loved and wanted, as well as deprived; and, with the onset of toilet training, of controlling and being controlled. That these do not disappear entirely with education and age is attested to by the misconceptions and surprising ignorance that pervade so many people's thinking about the functioning of the body. As Lewis Thomas, a distinguished medical researcher, currently chancellor of the Sloan-Kettering Institute for Cancer Research remarked, "Some of my most highly educated and intelligent non-medical friends...have the most bizarre ideas" of the way in which the human body functions (Bernstein, 1978). It is the bizarre quality of this realm of thought, as well as the degree of ignorance and confusion that pervade so many children's and adults' ideas about it, that gives credence to the belief that non-rational forces are at work.

Review of the Literature

Although Piaget (1976) investigated what children think with and where they believe dreams come from and Kreutzer, Leonard and Flavell (1975), along with others, have studied children's awareness of how they remember, studies of concepts of the functioning of internal body systems are rare.

In Bernstein and Cowan's study, "Children's Concepts of How People Get Babies" (1975), levels of thinking about external phenomena (Piagetian stages) are compared with the levels of thinking about an internal bodily function. In this case, however, the internal body process is not the children's but their mothers'. They found that children's conceptions of procreation follow a Piagetian developmental sequence.

The influence of affect on thought was studied by Gorman, a neuropsychiatrist (1969). He investigated this interaction in a study of physicians' concepts of the brain function and the stroke syndrome. He concluded that the drawings of the brain done by these physicians "possessed a strong subjective coloration." (p. 207)

Schilder and Wechsler (1935) asked children aged 4 to 13, "What is the inside of your body made of? What have you got inside your body?" They found that not until children reach the age of eleven can they give realistic answers to these questions. Young children usually said that the body contains recently eaten food.

Nagy (1953) was the first to attempt a large-scale systematic study of children's conceptions of some bodily functions (brain function, breathing and digestion). She did a series of studies in three countries--Hungary, England and the United States. The age range was different for each national sample, as was the number of subjects. The age range was 4:0 to 11:11 for the total sample and the total number of subjects was 750. She used three different methods--an interview accompanied by drawing the relevant organ within a given outline of the body (Hungarian sample), a written essay covering the same ground as the interview (English sample) and written responses to a questionnaire, read aloud to the whole class. All three were used with the American sample.

Gellert's monograph (1962), "Children's Conceptions of the Content and Functions of the Human Body," is a more detailed and extensive study than Nagy's. The major aims of her study were:

(1) To study developmental progressions in children's knowledge about the body; and

(2) To formulate hypotheses about the derivation of children's conceptions regarding the content and functioning of the human body.

Her sample consisted of 96 children, ranging in age from 4 years 9 months to 16 years 11 months, with equal numbers of boys and girls. Half the subjects fell

within the 5 to 10 year range. The subjects were patients hospitalized for a variety of acute and chronic physical disorders, and were of at least average intelligence. Most were children of working class families; 23% were private patients of middle and upper-middle socioeconomic status. Almost all were Caucasian and represented a variety of ethnic backgrounds, mostly Irish and Italian. All but a few had little or no formal teaching in human biology and anatomy.

Using a structured questionnaire[1] she interviewed the subjects individually. Although the questionnaire covered a number of body organs, systems and processes, we shall be concerned here only with digestive organs and processes. She asked the subjects questions and, at the same time, asked them to draw within lifelike outlines of a child's body and head (both front and back and different ones for boys and girls) various organs, etc. She found an increase, with age, in knowledge about the stomach, digestion and elimination. She also found little evidence of magical thinking in the younger children's responses, but considerable evidence of concrete thinking below age 9.

These and other findings relevant to ours will be discussed in greater detail later.

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[1] Gellert Index of Body Knowledge.

II. METHOD

A. Sample

The criteria for selection of the sample were age (representative of the cognitive developmental stages postulated by Piaget); socioeconomic status (middle-class); intelligence (average or above); attendance in a suburban public school district; and willingness on the part of the parents for their children to participate in the study.

Characteristics of the Sample: Age

The sample consists of 61 subjects--20 kindergarteners, 20 third graders and 21 seventh graders, with an equal number of boys and girls at each grade level except for the seventh grade, where there were 11 girls.[1]

The kindergarten subjects ranged in age from 5:0 to 6:0, the median age, 5:7½. (Table 1) The median age of the boys is slightly higher (5:8) than that of the girls (5:6); the range, 5:3 to 6:0 for the boys and 5:0 to 5:10 for the girls.

The third graders range in age from 8:2 to 9:2, the median age, 8:7½. The median age of the girls (8:8½) is slightly higher than that of the boys (8:6); the range, 8:2 to 9:2 for the girls and 8:2 to 9:0 for the boys.

The seventh graders range in age from 11:9 to 13:2, the median age, 12:8. The median age of the girls (12:8) is slightly higher than that of the boys (12:5); the range for the boys, 11:10 to 13:2, for the girls, 11:9 to 13:1.

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[1] The investigator spot-checked the tapes of the interviews as they were completed for audibility and clarity. Because the tape for one seventh grade girl seemed very soft, the investigator interviewed an additional girl. Since the transcriber transcribed the tape of her interview, by mistake, we are including her in the sample.

Table 1

Age of Sample: Median and Range									
	Kindergarten (N=20)			Third Grade (N=20)			Seventh Grade (N=21)		
	Girls (N=10)	Boys (N=10)	Total	Girls (N=10)	Boys (N=10)	Total	Girls (N=11)	Boys (N=10)	Total
Median	5:6	5:8	5:7½	8:8½	8:6	8:7½	12:8	12:5	12:8
Range	5:0-5:10	5:3-6:0	5:0-6:0	8:2-9:2	8:2-9:0	8:2-9:2	11:9-13:1	11:10-13:2	11:9-13:2

All but 4 of the children are Caucasian. There are 2 Chinese and 2 Black. They came from a large range of ethnic backgrounds, including Irish, Italian, Jewish.

Scores of WPPSI[1] or WISC[2] Vocabulary Tests. The scores of the kindergarten subjects on the WPPSI Vocabulary Test range from 106 to 155; the median score, 125. The scores of the third graders on the WISC Vocabulary Test range from 94 to 145; the median, 115. The scores of seventh graders on the WISC Vocabulary Test range from 92 to 155; the median, 124. (See Table 2)

Table 2

Scores on WPPSI or WISC Vocabulary Tests			
	Kindergarten - WPPSI (N=20)	Third Grade - WISC (N-20)	Seventh Grade - WISC (N=21)
Range	106 - 155	94 - 145	92 - 155
Median	125	115	124

[1] Wechsler Preschool and Primary Scale of Intelligence

[2] Wechsler Intelligence Scale for Children

Educational Background of the Sample with Regard to the Digestive System. The study of the digestive system was included in the science curriculum of the fifth, sixth and latter part of the seventh grade.

The Sample. In order to find out what the specific educational background of the third and seventh graders in the sample was, they were asked about their source of knowledge regarding the digestive system. All but two seventh graders said they had studied the digestive system at some time in school. (These two had been transferred from other school districts where it apparently was not taught.) Sixty-five percent of the third graders said they had learned about the digestive system in school. On further questioning, almost all mentioned such things as "health," "nutrition," "cleanliness" and body parts or organs.

B. Procedures

Formal procedures were set up by the principals with the investigator who was to interview the subjects regarding arrangements for interviewing the subjects. In the elementary schools, since the investigator went to the kindergarten and third grade classrooms to pick up the subjects, these procedures became much less formal as both the teachers and the children got to know the investigator. In the kindergarten and third grade classes, the teachers usually introduced the investigator to the child and then described, in very general terms, what was about to happen. Since the investigator and the child walked together to the room where the interview was conducted, there was a short time in which the investigator could talk more informally with the child about matters unrelated to the interview.

Although arrangements were made for the seventh graders to be told in advance what the purpose of the interview was, it did not work out that way. They just received a note from the guidance counselor's secretary, telling them to appear at a certain time in a specified room. As a result, the investigator explained to each

subject that this was part of a research project, described briefly different kinds of research including library research (which most of them had done) and explained that the method used in this study was to interview people in order to find out what their ideas were.

The interviews were taped in their entirety, including the children's remarks while drawing. The younger children were told about this before the interview started and most kindergarten children were given a chance to listen to a little, as they usually wanted to hear themselves. Each kindergarten and third grade child was interviewed individually in an unoccupied room in the school; the seventh graders, usually in the guidance counselor's office.

The data were gathered during two interview sessions that usually took place in the same week. All of the data reported here, with the exception of the drawing of a person, were obtained during the first session which lasted from a half to three-quarters of an hour. The second interview dealt with phenomena that did not pertain to the workings of the body (and are not reported here) and included the drawing of a person.[1]

The measures were administered in the following order: interview about the digestive system and its functioning; WPPSI or WISC Vocabulary Test; digestive process drawing (DPD). The vocabulary test was inserted between the interview and the drawing of the digestive process in order to reduce the chance of the graphic expression being a replica of the verbal expression. The drawing of a person was obtained at the end of the second session.

The introductions to each of the measures were the same at all age levels, except for the digestive system interview, which was more detailed for the third and seventh graders than for the kindergarten subjects. (See Appendix A) Since the digestive system interview was not only the most essential measure, but also

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[1] The drawing of a person was included to provide an additional index of intelligence. Scoring was done according to Harris (1963), although we had only one drawing unlike Harris who used drawings of both a woman and a man.

came first, the manner in which it was introduced was expected to set the tone for the rest. The investigator emphasized her interest in what the children thought happened to the food after it was ingested, even if they were not sure that they knew the correct answer. If their response to a question was "I don't know," they were generally asked to "guess" or "think about it." It was essential to help them relax so that they would express their ideas, whether or not they thought they were correct, i.e., so they would not treat this interview as if it were a test of their knowledge. In addition, the first two questions, "What is your favorite food?" and "What kinds of food don't you like?" were included only because it was hoped that talking about food would result in greater relaxation since they required no special information.

Standard introduction and procedures were used for the WISC and the WPPSI except for a slight modification in procedures with some kindergarten children. A child who could not respond was told, "Show me," where appropriate. Thus, for the word "shoe," pointing was considered acceptable. (See Appendix B)

Detailed directions were given for the drawing of the digestive process. The subjects were reminded that they had talked about "what happens to the food you eat." They were told specifically to "Show where the food goes, how it moves, what it looks like, and any changes in it." (See Appendix C) When the drawing was completed, if the child had not followed directions, the investigator reminded her/him, using the same language as before. After completion, all kindergarten subjects and most third graders were asked to tell the investigator what everything in the drawing was so she could label it. The seventh graders and some third graders who wanted to, labeled everything themselves. The labeling was monitored very closely to be sure everything in the drawing was labeled.

The instructions for drawing a person were simple, and emphasized drawing the whole person. (See Appendix D) When the drawing was completed, if the

investigator was not sure about some of the details, the child was asked specifically about them and the drawing was labeled appropriately. If the investigator was not sure of the sex of the person drawn, the child was asked of whom it was a picture.

C. The Measures

The digestive system interview and the digestive process drawing (DPD) were designed to provide two different media for presenting ideas about the functioning of the digestive system.

The digestive system interview is structured. It includes a number of leading questions, essentially the same at all age levels, each of which is followed by questions regarding details not mentioned spontaneously by the child. (See Appendix E) In addition, because the content was unfamiliar to most of the younger children and some questions covered territory unfamiliar even to the seventh graders, other questions were asked, tailored to the individual child, in order to stimulate responses as well as to clarify the meaning of the child's responses and ascertain that the desired content was included. Most of the questions pertain to the functioning of the digestive system. Others deal with the reasons for eating and the effects of cessation of eating. The content of the final questions is varied: sources of information about the digestive system, interest in this and other body systems, and memories of early concepts of what happens to food in the body.

For the digestive process drawing, since no body outline is presented, the child was free to draw whatever she/he considered appropriate. As indicated previously, the emphasis was on the process, what happens to the food, not on the digestive organs. Here, we were interested in the children's graphic concepts of the digestive process, how they might be similar to or different from verbally expressed concepts, as well as any features which might be indicators of affect.

The difficulties involved in drawing the digestive system, especially for the younger children who may not have seen any diagrams or pictures, are taken into consideration.

1. Analytic Methods and Categories Applied to The Interview.

Analysis of the interview data focuses on the content of the children's ideas about the digestive system and its functioning, the cues and data on which these ideas were based, and their explanations. Both quantitative and qualitative comparisons, by age level and sex, are made, content patterns are described and illustrative quotas from the interviews are provided.

The analysis of the responses to the digestive system interview is divided into two parts:

a. Substantive knowledge: Concepts of the functioning of the digestive system, of the end-products of digestion and assimilation and of the effects of cessation of eating.

b. Conceptual framework: The kinds of cues and data on which these concepts were based as well as the kinds of explanations that were offered.

a. Substantive knowledge: The functions of each digestive organ and the digestive, eliminative and assimilative processes associated with them determined the areas of analysis. A series of check lists was devised that dealt with the functions and processes of digestion, reasons for eating, and the effects of cessation of eating.

The check lists were derived from the responses of a sample of subjects from all three age levels, and included, for the most part, relevant items in the subjects' words. Other items were added when necessary during the tabulation of the data. The purpose of this procedure was to devise categories related as closely as possible to what the subjects actually said, that is, not in terms of correct responses. The data were tabulated by item, and then combined into

categories derived from these items. The analysis is divided into eight sub-sections, as follows:

(1) The sequence of food through the gastrointestinal tract, including the separation of nutrients from waste and the elimination of solid waste (in response to the question, "Where does the food go?"[1])

(2) Organs and body parts, related and unrelated to digestive/eliminative/assimilative processes.

(3) The processes by which food moves through the gastrointestinal tract (in response to the question, "Where does the food move?" or "What makes it move?")

(4) Digestive processes in each part of the digestive system (in response to, "What happens there?" with respect to each part mentioned.)

(5) Distribution of food to the body, the route by which it is transported and its form (in response to, "What happens to the food/nutrients?")

(6) Reasons for eating (in response to the question, "Why do you eat?")

(7) Comprehensiveness of overall concept of the digestive/eliminative/assimilative processes (a summary of the preceding material.)

(8) Effects of not eating (in response to the question, "What would happen if you stopped eating altogether?")

b. Conceptual Framework: This section of the analysis was concerned with the kinds of cues and data on which the subjects' concepts are based and the types of explanations offered. In many cases, no explanations were given. As a result, there are only a few areas in which these kinds of responses were given by a sufficient number of subjects to warrant comparison by age and sex.[2] These are:

(1) Responses stemming from the question, "Why do you eat?" involving explanations of how food keeps you alive, makes you strong, healthy; how you know you are hungry; how you know you are growing; and how the food gets to where it has to go in order to help you grow.

(2) Explanations of the color and consistency of food when in the stomach.

(3) Why food does not go to specified parts of the body.

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[1] And also to follow-up questions necessary to elicit responses. This applies to all the other questions cited in this list.

[2] Where there were only one or two explanations, they are often quoted in the preceding section.

(4) Transformation of matter into energy and other matter..

The categories, derived directly from the responses, are different, in some cases, at different age levels because of the different kinds of explanations given. They are a mixture of the nature of the basis of the explanation (e.g., physiological, biological, or nutritional information), type of thinking (e.g., quasi-animistic,[1] analogical), perceptual (e.g., intra-body sensations, visual), and others relating to specific explanations.

2. Analysis of the digestive process drawings (DPDs).

The analysis was divided into four parts:

a. Organs and body parts, related and unrelated to the diges ve/elimina-tive/distributive processes.

b. Depiction of where the food goes, indications of movement and of changes in it.

c. Presence or absence of a body outline.

d. Expressive characteristics.

As with the digestive system interview data, the categories used in analyzing the DPDs derive directly from the form and content of the drawings and take into consideration the differences at the three age levels. Age level comparisons are made, and sex differences noted.

The DPDs are compared with the interview data. This comparison is limited to the organs and body parts mentioned in the interviews and depicted in the drawings. Major digestive system organs and body parts, other digestive/distributive organs and body parts, and other organs and body parts not related to the digestive/eliminative/distributive system are compared, by age level only.

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[1] Defined for the purpose of this study as "Couched in animistic terms." That is, it does not imply that the subject conceives of parts of the body as "endowed with intentions." (Piaget's definition of animism, 1967, p. 26)

III. RESULTS

A. The Digestive System Interview

1. Substantive Knowledge

Analysis of the responses to the question, "What happens to the food after you put it in your mouth?" and to questions aimed at eliciting concepts of the digestive system follows.

a. Sequence of food through the gastrointestinal tract: kindergarten.

The descriptions given by the kindergarten subjects of the sequence of food through the gastrointestinal tract are not only very limited, but also contain many confusions and misconceptions. All subjects said that the food goes down the throat to the stomach. Three-tenths said it goes through a pipe/esophagus[1] as well as the throat. None mentioned the intestines.

Variation in frequency of response with regard to: (1) whether or not the food stays in the stomach (and, if so, some or all), and (2) whether or not food goes out of the body (and, if so, some or all) is shown in table 3.

Table 3

SEQUENCE OF FOOD THROUGH THE GASTROINTESTINAL TRACT - KINDERGARTEN

Sequence	Girls (N=10)	Boys (N=10)	Total (N=20)	Percent
A	4	2	6	30
B	1	3	4	20
C	5	3	8	40
D	0	2	2	10
Total	10	10	20	100

Sequence A - The food stays in the stomach; no mention of it going out of the body.
Sequence B - Some food stays in the stomach and some goes out of the body.
Sequence C - No mention of the food staying in the stomach; food goes out of the body.
Sequence D - No mention of food staying in the stomach or going out of the body.

[1] For the most part, the slash is used to indicate the term the subjects tend to use and the correct name of the organ or part of body.

Half of the kindergarten children (Sequences A and B) say that some or all the food stays in the stomach; three-fifths say that at least some of the food goes out of the body (Sequence B and C) and two-fifths do not mention elimination of solid waste at all (Sequences A and D).

None of the children distinguished verbally between food and waste, calling both what stayed in the body and what was eliminated "food."

The responses of those who mentioned elimination (three-fifths) were, for the most part, immediate, although there were occasional hesitations when describing it, possibly due to embarrassment. Most of them gave rather elaborate descriptions of elimination. Some of them described in detail that it happened in installments, e.g., "Just a little bit" of the food comes out "of the stomach...And then about two, three, two hours after, then maybe some more may." One child explained why elimination was necessary. "You have to get rid of it sometime...Because sometimes it gets not good for you any more...and then somehow you have to get it out, and that's the only way you can get it out." Another described what goes out as "food and drinks."

The kindergarten children's description of the sequence of food through the body contain three major misconceptions: (1) that some or all of the food stays in the stomach (50%); (2) that the food, in passing from the throat to the stomach, does not need to be enclosed in something (70%); (3) that elimination does not take place (40%).

Three of the children who said all the food stays in the stomach said later (in response to questions about the reasons for eating) that the food goes to various parts of the body. Despite reminders that they had said the food stayed in the stomach, they did not seem aware of the contradiction. It is possible that, for them, "stay" does not mean forever. Perhaps they had been told that food goes into the stomach and also that it goes to parts of the body to make them strong, big, etc., and they repeated both.

Third Grade. All the third graders said that the food went down the throat to the stomach, but only 55% said that it went through the pipe/esophagus as well as through the throat to the stomach. (See Table 4) Their descriptions of the rest of the sequence of food through the gastrointestinal tract are slightly less limited and more differentiated than those of the kindergarten children.

The major differences have to do with which parts of the gastrointestinal tract are included and the presence/absence of mention of elimination of food-waste.

Table 4

SEQUENCE OF FOOD THROUGH THE GASTROINTESTINAL TRACT - THIRD GRADE

Sequence	Girls (N=10)	Boys (N=10)	Total (N=20)	Percent
A	0	3	3	15
B	2	0	2	10
C	4	3	7	35
D	4	4	8	40
Total	10	10	20	100

Sequence A - Food goes through the throat and/or the pipe/esophagus to the stomach and/or intestine; no mention of elimination.
Sequence B - Food goes through the throat, through the pipe/esophagus to the stomach. All the food stays in the stomach except when you vomit.
Sequence C - "Food" goes out of the body from the stomach.
Sequence D - After it reaches the stomach, the food goes to the intestines and food-waste goes out of the body.

Twenty-five percent of the third graders (Sequences A and B) did not mention elimination of food/waste from the body except by vomiting, as compared with 40% of the kindergarten subjects. The remaining 75% who mention elimination (Sequences C and D) are divided among those (35%) who say that "food" goes out of the body from the stomach (Sequence C) and those (40%) who say that, after it reaches the

stomach, the food goes to the intestines and food-waste goes out of the body (Sequence D). None of the third graders mentioned the rectum.

Unlike the kindergartners, none of the third graders said that all the food stays in the stomach, but three-tenths said that some food stays in the stomach.

The third graders appeared to be more embarrassed about elimination than the kindergarten children. One child was so uncomfortable at first that he could not even describe what happens to the food in the gastrointestinal tract. At one point, however, he managed to say, "It goes out" but avoided saying anything else. Another said, "I'd rather not talk about it...It doesn't go out like little balls though. It goes out in different forms." Elimination is also alluded to in phrases such as, "You go to the bathroom" or "Then you get rid of it." Only one child mentioned "bowel movements" but only after the investigator tried to find out whether she was talking about urine (because she had mentioned kidneys) or feces. She said, "The bad stuff - then it goes down into your - into your bowel movements and then (when?) you go to the bathroom in the night...then it comes out."

The distinction between nutrients and waste and their separation is mentioned by only one-fifth of the third grade children. (See Table 5) All of these said that separation takes place in the intestines. Only two of these, however, referred to what goes out of the body as "waste."

Table 5

SEPARATION OF NUTRIENTS FROM WASTE - THIRD AND SEVENTH GRADES

Category	Third Grade (N=20)				Seventh Grade (N=21)			
Separation takes place:	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
In stomach	0	0	0	0	4	0	4	19
in large intestine	0	0	0	0	0	2	2	10
in small intestine	0	0	0	0	3	1	4	19
in intestine (large or small not specified)	3	1	4	20	2	3	5	24
in other organs	0	0	0	0	0	3	3	14
location unclear	0	0	0	0	1	0	1	5
no mention of separation	7	9	16	80	1	1	2	10
	10	10	20	100	11	10	21	101

Seventh Grade. The seventh graders' responses are very similar with respect to the early part of the sequence of food. All but one said that the food goes through the throat and/or esophagus to the stomach. One subject said it goes down the windpipe to the small intestine. They are in total agreement about the end of the sequence, that elimination takes place. There are, however, different versions of what happens in between, as shown in table 6.

Table 6

SEQUENCE OF FOOD/WASTE THROUGH THE GASTROINTESTINAL TRACT - SEVENTH GRADE

Sequence	Girls (N=11)	Boys (N=10)	Total (N-21)	Percent
A	1	1	2	10
B	3	2	5	24
C	0	1	1	5
D	2	2	4	19
E	2	4	6	29
F	3	0	3	14
Total	11	10	21	101

Sequence A - Food goes only to the stomach.
Sequence B - Food goes from the stomach to intestines (small or large unspecified).
Sequence C - Food goes from the stomach to the large intestine.
Sequence D - Food goes from the stomach to the small and then to the large intestine.
Sequence E - Both food and waste go to the intestines.
Sequence F - Waste alone goes to the intestines.

Almost half the subjects (Sequences B, C, D) say the "food" goes to the intestines (large, both or unspecified) while only one-tenth do not mention intestines at all (A). The rest (43%) say that either "waste" alone (F) or both "food" and "waste" (E) go to the intestines. Despite the investigator's attempts to get them to clarify the meaning of "nutrients," "food," and "waste," and despite the fact that the location of the separation of nutrients was specified by 86% of

the seventh graders (see Table 5), there is obviously some confusion in the minds of many - either about what (nutrients, food or waste) goes where or, possibly, just about the terminology.

Nine-tenths of the seventh graders mentioned the separation of nutrients from waste (as compared with only 20% of the third graders), and all but one of these specified clearly, in response to questioning, in which part of the digestive tract this separation takes place. (see Table 5) The location most frequently mentioned (53%) is the intestines - large, small or unspecified (10% in the large and 1% in the small intestine). Almost a fifth said this separation takes place in the stomach. Other organs (mentioned by one subject each) were the liver, the trachea and both the esophagus and the stomach. Thus, only 1% were aware that separation takes place in the small intestine and that only the waste then goes to the large intestine.

In general, there is considerable lack of clarity about what happens after the food leaves the stomach - about the sequence as well as about what exactly is eliminated.

In most cases, their responses about elimination were straightforward and unhesitant. They are not, however, couched in physiological terms[1] so that they often appear to be evasive and, sometimes, distancing. For example: "and the waste goes out;" "it goes into what you call it, glands, I guess, to be disposed of;" "and then you have to go to the bathroom;" "you put it out...you get rid of it." No one mentioned either bowel movement or the rectum.

To sum up: There are age level differences in the descriptions of the sequence of food through the gastrointestinal tract. The degree of knowledgeability and differentiation increases with age; the kinds of confusions and misconceptions

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[1] Although the third graders tended to use the same kind of language, they had not studied the digestive system and. therefore, could not be expected to use physiological terms.

also vary with age. At the same time, although almost all the seventh graders studied the digestive system, the responses of many are unclear; their descriptions are often inaccurate with regard, particularly, to the sequence of food after it leaves the stomach; the point at which the nutrients are separated from the waste; and the distinction between nutrients, food and waste.

b. Organs and body parts, related and unrelated to digestive, distributive and eliminative processes.

In response to the questions about the processes involved in digestion, distribution of nutrients and elimination of waste, the subjects named organs and body parts in which they thought these processes took place.

The major digestive organs mentioned by the kindergarten children are the pipe/esophagus, the tummy/stomach, and, by only one child, the liver. (See Table 7) In addition to those mentioned by the kindergartners, some third graders either specified the small and/or large intestine or mentioned the intestines in general. The seventh graders added to these only the pancreas. Thus, the total number of organs mentioned increases with age: Kindergarten, 4; third grade, 5; seventh grade, 6.

Table 7

MAJOR DIGESTIVE ORGANS AND BODY PARTS

	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Mouth[1]												
Esophagus/tube/pipe	2	3	5	25	9	8	17	85	11	9	20	95
Stomach/tummy/belly	10	10	20	100	10	10	20	100	11	10	21	100
Intestines/tubes (gen.)	0	0	0	0	3	4	7	35	2	2	4	57
Small intestine	0	0	0	0	3	1	4	20	8	7	15	71
Large intestine	0	0	0	0	2	0	2	10	8	6	14	67
Pancreas	0	0	0	0	0	0	0	0	0	3	3	14
Liver	0	1	1	5	1	0	1	5	2	4	6	29
Rectum/anus/bowels	0	0	0	0	0	0	0	0	0	0	0	0

[1] The mouth is not included because it is mentioned by the investigator in the first question of the interview.

The number mentioned by at least half the subjects also increases with age.[1] The only one mentioned by more than half the kindergartners is the stomach, and all of them mentioned it. All the third graders also mentioned the stomach; 85% the pipe/esophagus and a total of 55%, the intestines, some of whom specified the small and/or the large intestine (a total of 3). All the seventh graders mentioned the stomach; 95% the pipe/esophagus; 67%, the large intestine and 71%, the small intestine, with 91% mentioning the intestines either generally and/or specifically (a total of 4 out of a possible 7).[2]

One outstanding similarity is that no one in the sample mentioned by name any parts of the body involved in the elimination of solid waste. There appear to be no sex differences at any age level with regard to the mention of any major organ.

Other organs and body parts related to the digestion and distribution of food or the elimination of waste products were also mentioned by many subjects. (See Table 8) Kindergartners mentioned teeth, the tongue, throat or neck, pipes/bloodstream carrying food to the body and a "little pipe" from the liver to the heart (a total of 5). Third graders mentioned, in addition, salivary glands and kidneys, but not the "little pipe" (a total of 6). And seventh graders added to these a valve-"flap" between the duodenum and stomach, "cilli"/"cilia"/villi in the small intestine, kidneys and bladder. A few also specified, in addition to pipes/bloodsteam in general, main arteries and capillaries (a total of 11). Here also there is a distinct increase, with age, in the number of organs mentioned. When we look, however, at those mentioned by at least half the subjects at each age level, we find that the responses are very similar. There are only two at all age levels

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[1] Descriptions of the character of response evoked in more than half of the subjects in each age group are given, where appropriate, in order to report modal response patterns.

[2] Since over half mentioned both the large and small intestines, here we are not counting intestines (general) as a separate organ.

and the same ones are mentioned by the third and seventh graders. Half the kindergartners mention teeth, and all, the throat or neck. Both the third and seventh graders also mention the throat or neck (third grade, 100%; seventh grade, 81%) and the pipes/bloodstream carrying food, as well (third grade, 70%; seventh grade, 91%).

Table 8
OTHER ORGANS AND BODY PARTS RELATED TO DIGESTION, DISTRIBUTION OF FOOD AND ELIMINATION OF WASTE

	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Teeth	2	8	10	50	3	3	6	30	0	1	1	5
Tongue	1	1	2	10	3	2	5	25	0	1	1	5
Salivary glands	0	0	0	0	1	0	1	5	1	0	1	5
Throat/neck	10	10	20	100	10	10	20	100	10	7	17	81
Valve "flap" between stomach and duodenum	0	0	0	0	0	0	0	0	1	1	2	10
Villi/"celli" in small intestine	0	0	0	0	0	0	0	0	1	1	2	10
Little pipe from liver to heart	0	1	1	5	0	0	0	0	0	0	0	0
Bloodstream/pipes etc. with nutrients	1	4	5	25	6	8	14	70	10	9	19	91
Main arteries	0	0	0	0	0	0	0	0	1	2	3	14
Capillaries	0	0	0	0	0	0	0	0	0	3	3	14
Kidneys	0	0	0	0	1	1	2	10	0	1	1	5
Bladder	0	0	0	0	0	0	0	0	0	1	1	5

There are some noteworthy age level differences with regard to major and other related organs and body parts. While all the subjects mention the stomach, not until the third grade are they generally aware that there is some sort of tube or pipe through which the food passes to get from the throat to the stomach

(kindergarten, 25%; third grade, 85%; seventh grade, 95%). Although mention of intestines (in general) increases from only 35% at third grade to 57% at seventh grade, the percentage of seventh graders who mention the small intestine is 71%, a 51% leap from the 20% of the third graders. With respect to the large intestines, the change is even greater - from 10% at third grade to 67% at seventh grade. In relation to the bloodstream carrying nutrients to the body, there is a very large increase at the third grade level and another large increase at the seventh grade level (kindergarten, 20%; third grade, 70%; and seventh grade, 91%).

The largest sex difference was found at the kindergarten level where four times as many boys (8) as girls (2) mentioned teeth.

A few subjects mentioned organs not related to digestion at all. At all three age levels, the heart is mentioned by one or two subjects. One third grader and one seventh grader mentioned the tube/cord/trachea; one third grader, tonsils, and one, the lungs, while one seventh grader mentioned the appendix.

c. Processes by which food moves through gastrointestinal tract.

During the detailed questioning about what happens to the food in the gastrointestinal tract, the subjects were asked, among other things, how the food moves from one part to the others.

The principal processes were mentioned by the sample as a whole - swallowing and slipping or sliding. Because of their limited concept of where the food goes, the kindergarten children were concerned only with how the food moves from the mouth to the stomach. Almost all (95%) mentioned swallowing, one-fifth said that blood carries the food from the throat to the stomach, and 35% mentioned that the food slips or slides from the throat to the stomach. (See Table 9)

All the third graders mentioned swallowing. Half said the food slipped or slid, or saliva or "drinking" helped the food slide from the throat to the stomach or from the pipe/esophagus to the intestine or through the pipe/esophagus. One-tenth said the "blood" carries the food from the throat to the stomach; 10%, that the food moves from the throat through the pipe/escphagus by "gravity." One of these said, "in the tube...little hairs - when you're laying down, brush it (the food) into your stomach...and gravity." When asked to explain about gravity, she said, "Because we were studying about the moon and the earth...Well, the earth pulls the food down from your esophagus down into the stomach." Another third grader who mentioned gravity said, when questioned, "'Cause gravity forces things to come down."

Other processes were mentioned by some. One said that the "tongue pushes" the food; another, that saliva, air and the muscles of the arms and body push the food down and "when it goes down, the blood hits it."

Although the third graders know about swallowing and slipping/sliding, the variety of other responses given by some attests to the confusion about what the inside of the body is like and what goes on in the gastrointestinal tract.

Table 9
PROCESSES BY WHICH FOOD MOVES THROUGH THE GASTROINTESTINAL TRACT

	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
Processes[1]	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Muscles or contractions	0	0	0	0	0	0	0	0	6	5	11	52
Swallowing	10	9	19	95	10	10	20	100	11	9	20	95
Slips/slides/saliva, etc.	4	3	7	35	3	7	10	50	5	6	11	52
Blood carries/pushes food	2	2	4	20	1	1	2	10	2	0	2	10
Gravity/falls	0	0	0	0	1	1	2	10	1	2	3	14
Other	0	1	1	5	3	0	3	15	3	3	6	29

[1] These are overlapping categories. More than one response could be given by each subject. As a result, the percentages do not total 100%.

Only seventh graders (52%) specifically mentioned muscular contractions in the throat and/or esophagus and/or other parts of the gastrointestinal tract. None used the word peristalsis to describe the process in general. They are similar to the younger children with respect to swallowing (95%), slipping/sliding, etc. (52%) and in the attribution of movement to gravity (14%), and to blood and "hairs"/ "cilia" in the esophagus, by a few.

It is not surprising that, at all age levels, the subjects tend to be aware of the effects of voluntary actions (swallowing or drinking liquids), as well as what is perceived through their senses (saliva in the mouth), as agents of movement in the gastrointestinal tract. Thus, the only age level difference between the seventh graders and the younger subjects is in the seventh graders' awareness that muscular contractions are also responsible for the movement of food.

Misconceptions, e.g., the role of blood and gravity in the movement of food through the gastrointestinal tract, are expressed by a similar proportion of subjects at each age level.

The difference in the number of third grade girls (3) and boys (7) who mention slipping/sliding is suggestive of a sex difference.

d. Digestive processes in the gastrointestinal tract.

At all ages the subjects were asked what happens to the food in each of the organs of the gastrointestinal tract mentioned. The words "digest" or "digestion" were not used, although follow-up questions were aimed at finding out their concepts of digestive processes.

Kindergarten. The kindergarten subjects were mainly aware of what they did to food, that is, what happened to it in their mouths, but of very little else.[1] All of them said they bit and/or chewed the food. (See Table 10) But the immediate

[1] But the first question, "When you put the food in your mouth, what do you do?" suggests that kind of response.

response of many to the question, "Why do you chew it?" elicited a variety of explanations having very little to do with the digestive process. For example, "Because sometimes my mother cooks curry and I like curried chicken." Or "Because you are not supposed to suck it." Many also mentioned that, if you swallow without chewing, you'd choke. Although much questioning was necessary, nine-tenths eventually said that biting and/or chewing "breaks" or "chops" the food up into smaller pieces. One child mentioned dissolving action in the mouth, i.e., saliva makes the food moist.

One-fourth mentioned that something happens to the food in the stomach (e.g., that the food "gets into smaller pieces," "digests"). Of these, only 10% were aware that some sort of mechanicals or muscular action takes place there (e.g., the stomach "turns" or "churns" the food). Three-fifths specifically said that "nothing" happens to the food in the stomach. For kindergarten subjects, the stomach is essentially a place where the food is stored. Since none of the subjects mentioned any other digestive organ, no other digestive process was mentioned.

Third Graders. All the third graders mentioned that they chewed their food, all but one (95%) that chewing breaks the food into smaller pieces. (Table 10) They differ from the kindergarten children in that many fewer needed further questioning to elicit the reason for chewing food. Some also said that you chew the food so that you can taste it. For example, (I) "bite it so I can taste it." Others said that you chew to prevent choking. "'cause if (it's) chewed it goes down and it's not in big chunks 'cause if it was in big chunks you'd choke on it."

Two-fifths mentioned the dissolving/liquefying effect of saliva in the mouth; one-fifth indicated that saliva facilitates chewing and/or swallowing food. None mentioned chemical (enzymal) action by saliva in the mouth. Fifteen percent said

that food "gets into bigger pieces when it goes down the pipe" (esophagus) and/or that food gets mixed up in the esophagus.

They differ from the kindergarten subjects in that more are aware that something happens to food in the stomach. Only one-fifth said nothing happens in the stomach, as compared with three-fifths of the kindergarten subjects. One-quarter of the third graders mentioned some sort of mechanical/muscular action (e.g., that the food is broken down or mixed up, that the stomach "turns," "churns," or "acts on" the food). Three-tenths mentioned dissolving action in the stomach (the food "dissolves" or "turns into liquid"). One of these said, "It mixes with juices...then it makes it moist so that bad stuff can get out of you easier." Half mentioned "other" things that happen to food - mainly the result, not the nature, of the stomach's action (e.g., food gets into "smaller pieces" or gets "mushed up"). One mentioned "chemicals," possibly implying chemical action, but did not describe its effect. Although two-fifths mentioned intestines, only one mentioned what happens there (food gets mushed up).

Table 10

DIGESTIVE PROCESSES IN THE GASTROINTESTINAL TRACT

Category [1]	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
In Mouth												
Muscular/mechanical action												
chewing/or biting	10	10	20	100	10	10	20	100	11	10	21	100
chewing/or biting breaks up food	8	10	18	90	10	9	19	95	11	10	21	100
Dissolving/liquifying action												
of saliva	0	1	1	5	4	4	8	40	9	8	17	81
Chemical action												
enzymes in saliva	0	0	0	0	0	0	0	0	0	1	1	5
In Esophagus	0	0	0	0	2	1	3	15	2	2	4	19
In Stomach												
Digestive processes (total)	3	2	5	25	7	9	16	80	11	9	20	95
Muscular/mechanical	2	0	2	10	1	4	5	25	4	2	6	29
Dissolving/liquifying	0	0	0	0	2	4	6	30	4	5	9	43
Chemical action (total)	0	0	0	0	0	1	1	5	6	8	14	67
By digestive juices/acids	0	0	0	0	0	0	0	0	4	4	8	38
Sources of digestive juices	0	0	0	0	0	0	0	0	2	4	6	29
Effect of enzymes	0	0	0	0	0	0	0	0	0	1	1	5
Implied	0	0	0	0	0	1	1	5	0	0	0	0
Other	2	2	4	20	4	6	10	50	6	3	9	43
Nothing happens	6	6	12	60	3	1	4	20	0	0	0	0
In Intestines												
Mechanical ("mushed up")	0	0	0	0	1	0	1	5	1	2	3	14
Dissolved by juices	0	0	0	0	0	0	0	0	0	1	1	5
In Liver												
Chemical process unspecified	0	0	0	0	0	0	0	0	1	1	2	10

[1] Many sub-categories overlap. Thus the percentages do not total 100%.

Seventh Graders. Seventh graders are considerably more aware of digestive processes than are third graders. Like the third graders, all the seventh graders said that chewing breaks the food into little pieces. Further questioning was not required to elicit this response, except for a few who apparently thought that something less obvious was being asked about, and hesitated. In addition to this, a few also said that chewing was important in order "to get the flavor out;" a few said you would choke if you did not chew; and others pointed out that chewing would make the food easier to digest.

Four-fifths mentioned the dissolving/liquefying action of saliva in the mouth, one specifying that the "salt" in the saliva dissolves the food (possibly implying some sort of chemical action. (See Table 10) Enzymes in the saliva are specifically mentioned, but not what they do, by one seventh grader only.

Almost a fifth mentioned actions taking place in the esophagus -- in this respect being no more knowledgeable than the third graders.[1] One of these mentioned that "the body starts taking the rich vitamins out of it (the food) and then it separates the fats from the carbohydrates."

Where the seventh graders clearly differ from the younger subjects is in their awareness of the digestive processes in the stomach, particularly the chemical processes. Ninety-five percent mentioned one or more digestive processes. Twenty-nine percent mentioned mechanical/muscular action; 43%, dissolving/liquefying actions; and 67% chemical actions.[2] Among the 67% who describe "chemical" actions, 38% mentioned digestive juices/acids; 29%, specific sources of digestive juices (stomach, pancreas, liver), and one mentioned "enzymes" and what they do.

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[1] Since no digestive action takes place in the esophagus.

[2] "Chemical" is used here very broadly, including any mention of "digestive" juices or "acids."

Here, the figures mask the evident confusion of some, as illustrated by the following quotes:

> "In the stomach a lot of these acids come out from the stomach's walls and turn it into gooey soup or something."
>
> "Any hard things like bones get dissolved by an acid and the rest just keeps on going through. It may stay there for a little while until it gets dissolved." (.?.) "Hydrochloric acid." It dissolves "anything that it's not used to...that you haven't eaten in a long time." (.?.) "Like fish, you may eat one (bone) by accident."
>
> "Some other juices, I don't know if...bile or not." (.?.) "from some place else it comes to the stomach." (.?.) "some moisture comes from the walls of the stomach."

Forty-three percent gave some even vaguer responses(e.g., "food gets into smaller pieces," "digests," "proteins are broken down;") but 29% of these gave other responses as well. Only 14% mentioned vague actions in the stomach and no other.

Digestive processes taking place in the intestines were mentioned by 19%. Of these, three subjects described the effects of mechanical actions (food gets "mushed up," "chewed up," "more liquidy") and one, a chemical action -- "it (food) gets dissolved by more juices...and I think it gets broken down into single molecules." Two described the results of a chemical process, but not the process itself, that takes place in the liver -- fat turns into "energy," proteins into "bile." No other digestive processes were mentioned.

The only similarity in the responses at all age levels is the degree of awareness that biting and chewing break up food into smaller pieces. The amount of questioning needed to elicit responses regarding the effects of these actions, however, decreased with age.

The third graders are aware of more digestive processes than the kindergarten subjects, and more of them are aware of digestive processes that take place in the stomach. The seventh graders, as expected, are aware of more digestive organs and also of more digestive processes that occur in them. Their

understanding of digestive processes other than mechanical/muscular and dissolving actions, however, does not match their knowledge.

There appear to be no sex differences with respect to knowledge of digestive processes at any age level.

e. Distribution of food to the body.

This section includes four sub-sections: (1) whether or not the food is distributed to the body and, if so, to some or all parts; (2) parts of the body to which the food goes; (3) the route by which the food is transported; and (4) the form in which the food is transported.

(1) Distribution to the body. Half the kindergarten subjects said that the food is distributed to the body (Table 11). Fifteen percent said it goes to all parts of the body; and half specified one or more parts or organs to which the food goes.

In contrast, nine-tenths of the third graders said the food is distributed to the body. One-tenth said it goes to parts of the body where needed; 65% specified the organs or body parts to which the food goes; and 25% did not name any.

Although the seventh graders are similar to the third graders in the percentage who said food goes to the body (95%), many more (62%) said food goes to parts of the body where it is needed and seven-tenths named one or more body parts or organs to which the food goes.

Table 11

DISTRIBUTION OF FOOD TO VARIOUS PARTS OF THE BODY

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Food goes to all Parts of body	1	2	3	15	4	3	7	35	6	5	11	52
Food goes to parts of body where needed	0	0	0	0	1	1	2	10	6	7	13	62
One or more parts or organs specified	3	7	10	50	7	6	13	65	7	8	15	71
Food goes to unspecified parts of body	0	0	0	0	3	2	5	25	0	0	0	0
Total: mention of distribution to body	3	7	10	50	10	8	18	90	9	10	19	95
No mention of distribution to body	7	3	10	50	0	2	2	10	1	0	1	5

(2) Parts of body to which food goes. All the subjects who said that the food goes to the body were asked to name parts of the body to which the food goes, but no attempt was made to get a complete list from them. As a result, the numbers given below (Table 12) are to be considered only as suggestive.

More kindergarten boys than girls (70% and 31% respectively) specified the parts of the body to which food goes, and more parts were named by boys than girls (ten, as compared with three). None of the girls mentioned more than one part of the body, while all but one of the boys mentioned from two to six parts.[1] (Table 12) Arms, legs and muscles (30% for each) were mentioned most frequently.

Of the third graders who mentioned specific parts, arms and legs were mentioned most frequently (45% and 40% respectively), as they were by the kindergarten subjects. They mentioned twelve other parts of the body while the kindergartners

[1] Although there were variations in questioning from subject to subject (in response to individual differences), there were no systematic differences in terms of age or sex.

mentioned eight other parts. There appears to be no sex difference with respect to the number of specific parts mentioned (eleven and twelve, respectively).

Seventh graders mentioned legs (29%), muscles and heart (33% each) most frequently. More of them mentioned the heart than do the younger subjects. Both boys and girls mentioned from one to five body parts or organs to which the food goes. A total of ten body parts or organs were mentioned by seventh graders (eight by girls, nine by boys).

A few subjects, at each age level, spontaneously mentioned parts of the body to which the food did not go and sometimes also explained why. (see pp. 61-62) They tended to mention the head, or parts located in or on the head (brain, mouth, ears, hair, nose, teeth). Others mentioned arms, throat, knees, fingernails, toenails, knees, bones, shoulders.

Table 12

SPECIFIC PARTS OF BODY TO WHICH FOOD GOES

Part of Body	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Arms	1	5	6	30	5	4	9	45	3	1	4	19
Legs	0	6	6	30	6	2	8	40	3	3	6	29
Muscles	1	5	6	30	2	2	4	20	2	5	7	33
Heart	0	1	1	5	3	1	4	20	4	3	7	33
Brain	0	2	2	10	3	1	4	20	2	1	3	14
Bones	0	0	0	0	0	0	0	0	1	4	5	24
Feet	1	1	2	10	0	2	2	10	0	0	0	0
Chest/Trunk	0	0	0	0	1	0	1	5	1	0	1	5
Head	0	2	2	10	2	1	3	15	0	0	0	0
Hands	0	1	1	5	1	0	1	5	0	0	0	0
Lungs	0	0	0	0	0	0	0	0	1	1	2	10
Eyes	0	0	0	0	1	0	1	5	0	0	0	0
Fingers	0	2	2	10	1	1	2	10	0	1	1	5
Toes	0	0	0	0	1	1	2	10	0	0	0	0
Skin	0	0	0	0	0	0	0	0	0	1	1	5
Back	0	1	1	5	1	1	2	10	0	0	0	0
Neck	0	0	0	0	0	2	2	10	0	0	0	0

(3) Route of food distribution. Twice as many kindergarten subjects said that food went to various parts of the body as were aware of the way in which it gets there. Thus, one-quarter said, either spontaneously or in response to questioning, that the food went to the body via "pipes," "nerves," etc.--their names for blood vessels or bloodstream. (Table 13) Fifteen percent said it moved from the stomach and one subject, that it moved from "a pipe" (intestines) into the bloodsteam. Only one mentioned a component of the nutrients--vitamins.

Table 13

MOVEMENT OF FOOD INTO THE BLOODSTEAM

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Process specified	0	0	0	0	0	0	0	0	0	1	1	5
components of nutrients specified	1	0	1	5	0	0	0	0	6	5	11	52
Move into bloodsteam:												
from stomach	0	3	3	15	2	4	6	30	4	0	4	19
from esophagus and stomach	0	0	0	0	0	0	0	0	0	1	1	5
from intestines	0	1	1	5	2	4	6	30	2	3	5	24
from large intestine	0	0	0	0	0	0	0	0	0	2	2	10
from small intestine	0	0	0	0	0	0	0	0	3	1	4	19
from liver	0	0	0	0	0	0	0	0	0	1	1	5
from trachea	0	0	0	0	0	0	0	0	0	1	1	5
location unspecified	1	0	1	5	1	0	1	5	0	0	0	0
Movement implied	0	0	0	0	1	0	1	5	0	0	0	0
"Waste"/food goes into blood	0	0	0	0	0	0	0	0	1	0	1	5
Total: Movement into blood	1	4	5	25	6	8	14	70	10	9	19	91

A large proportion of third graders (70%), as compared with kindergarten subjects, indicated that the bloodstream was the means of transport of food to the body, suggesting greater sophistication on their part. Three-tenths said the food goes into the blood from the stomach, and the same percentage said it goes from the intestines. (Table 13)

Almost all the seventh graders (91%) said that food is distributed to the body via the bloodstream; it was unclear what the route was for one, and one did not mention distribution of food to the body at all (Table 13) One subject described the bloodstream as follows: "...it's like a street, the bloodsteam is like a street and the food is like the cars, and then the bloodstream just carries it."

Of those who said the nutrients were distributed via the bloodstream, only one specified the process as "diffusion." (Table 13) Fifty-two percent specified one or more components of nutrients (e.g.,oils and fats, carbohydrates, vitamins, minerals, proteins). Eighty-five percent specified the part of the digestive tract from which the nutrients moved into the bloodstream. Most frequently mentioned were the stomach (19%), the intestines (24%), and the small intestine (19%).

(4) Form in which food is transported. When asked what the food was like when it was in the bloodstream, one-tenth of the kindergarten subjects indicated it was in liquid form (e.g., "red blood") and 15%, in solid form, e.g., "little pieces of pizza," "meat" (indicating that it was like flesh under the skin) or mushy pieces of food. (Table 14) Of those (one-fifth) who did not specify the route, two said mushed-up food, and the others said, possibly in the form of pieces of food.

Twice as many third graders as kindergartners were able to describe the form in which the food was when in the bloodstream (50% and 25% respectively).

(See Table 14) Three-tenths said it was in liquid form, e.g., "a little bit of blood," "blue like blood," before "it hits the air and turns red." One-fifth said it was in solid form. The most graphic description was "like three worms crushed together with deer meat." Others said "little pieces of chicken," or "mush."

Table 14

FORM IN WHICH FOOD IS DISTRIBUTED TO BODY

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Via bloodstream: liquid-clear/red/ like blood/blood	0	2	2	10	2	4	6	30	7	5	12	57
solid (total)	1	2	3	15	3	1	4	20	2	1	3	14
very small pieces/ particles	0	0	0	0	0	0	0	0	1	1	2	10
pieces of meat/ food/chicken	0	1	1	5	1	1	2	10	0	0	0	0
"meat" (flesh)	0	1	1	5	0	0	0	0	0	0	0	0
mushy/mushy pieces of food	1	0	1	5	2	0	2	10	0	0	0	0
mixture of liquid and pieces of food	0	0	0	0	0	0	0	0	1	0	1	5
cells, molecules, microscopic	0	0	0	0	0	0	0	0	1	3	4	19
Total	1	4	5	25	5	5	10	50	10	9	19	91
Route unclear--pieces of food	0	0	0	0	0	0	0	0	0	1	1	5
No route specified--mushy, etc.	2	2	4	20	1	0	1	5	1	0	1	5

More than half of the seventh graders (57%) said the nutrients went into the bloodstream as a liquid (e.g., like blood, or blood); 14%, that they were in solid form or a mixture of solid and liquid; and 19%, that they were in the form of "cells" or "molecules" or were "microscopic." (Table 14) The one subject who was unclear about how the food was transported to the body thought it went in the form of pieces of food.

Comparing the three age groups: with regard to the bloodstream as the route by which food/nutrients is distributed to the body, the third graders were more similar to the seventh graders than to the kindergartners. Although some seventh graders are still under the impression that the food, when in the bloodstream, is in solid form, as are approximately the same proportion of kindergartners and third graders, a much larger proportion of seventh graders than younger subjects say that it is in the form of a liquid or of microscopic cells or molecules. As one seventh grader put it, "I can't imagine a piece of lasagne floating around in the bloodstream."

Although the numbers are very small, there is a slight suggestion of a sex difference at the kindergarten level, more boys than girls being aware of the distribution of food to the body and of the bloodstream as the means of transport. That there also are more boys than girls who specified parts of the body to which food goes, as well as the number of parts per subject mentioned, suggests that kindergarten boys may be more knowledgeable about parts of the body and the role of the bloodstream in the distribution of food to the body.

There appear to be no sex differences at the third or seventh grade levels.

f. Reasons for eating.

When asked, "Why do you eat?" the subjects of all ages tended to talk about the end product of eating -- mainly, growth, strength, energy, health and being alive.

Most of the kindergarten subjects mentioned only one reason for eating, and a few, two or three. Most frequently mentioned were growth (55%) and strength (40%). (Table 15) Being strong almost always meant to them that "muscles get bigger." "It (food) builds up the muscles." One child said, strong means "like you can punch really hard."

To grow was interpreted as "getting bigger," growing up; age and size are sometimes confused. Fifteen percent indicated that eating was necessary in order to stay alive, e.g., "'cause if you don't eat, you die very quick" or "so you don't die." Only 35% said that they ate because they were hungry and one child mentioned that he ate because it was time to eat. None said that they ate because they enjoyed food although, when reminded that they had said they liked certain foods, they agreed that this was a reason for eating.

Most of the third graders mentioned two reasons for eating. They mentioned energy most frequently (50%) and to keep alive (40%). (Table 15) The latter was usually expressed negatively -- "so you won't die." Although they did not know what energy was, they knew what it did. When asked, one subject explained that eating "helps your brain...and your heart...It feeds the brain and it makes it (the heart) pump...It makes you energy or makes you think faster." Some saw it in terms of physical activities, e.g., food "makes a lot more energy to do stuff...like to run." Or "like so you can get up and walk around--not just sit in bed all day and can't get up." Others, in terms of mental activities, e.g., "If I eat now an apple and I'll have enough energy for three hours of reading," or "So I'll know things better, like so that more food will go up to my brain."

Growth was mentioned much less frequently (10%) than by the kindergarten subjects. Eating in order to be healthy (20%), for strength (30%), and in order to function (20%) were also mentioned. Only one-fifth said they ate because they were hungry, but some (15%) said they ate because they enjoyed food.

Table 15

REASONS FOR EATING

Category[1]	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N-20)[2]			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
End Products												
Growth	5	6	11	55	0	2	2	10	5	2	7	35
Strength	4	4	8	40	3	3	6	30	3	6	9	45
Energy	1	0	1	5	5	5	10	50	2	4	6	30
To stay alive	2	1	3	15	3	5	8	40	6	5	11	55
Health	2	1	3	15	2	2	4	20	2	6	8	40
To function	0	0	0	0	3	1	4	20	2	1	3	15
Other												
Fuel for body	0	0	0	0	0	0	0	0	0	1	1	5
Hunger	3	4	7	35	3	1	4	20	6	7	13	65
Enjoyment/taste	0	0	0	0	0	3	3	15	3	1	4	20
Time to eat	0	1	1	5	0	0	0	0	0	0	0	0
Parents say so	0	0	0	0	0	0	0	0	1	0	1	5

[1] These are overlapping categories; a subject may mention more than one.

[2] One girl was not asked, "Why do you eat?"

Eating to stay alive was mentioned most frequently by seventh graders (55%). As compared with the third graders, they tended to use positive, rather than negative terms to explain what being alive meant; e.g., "The minerals and stuff keep the parts of the body that need it working." Growth was not mentioned

by as large a proportion of seventh graders (35%) as of kindergartners, while energy was mentioned less frequently (30%) than by third graders.

A large proportion (65%) mentioned hunger as a reason for eating. Here, they seem to be more in touch with their own feelings and motivations than either the kindergarten or third grade subjects, who seem, for the most part, to be parroting what they were told by adults. One-fifth also said they ate because the food tasted good or they enjoyed eating. Only one mentioned eating because of boredom, or for social reasons--"When I'm with my friends, we all buy a pizza; you know, I take a slice too."

In general, the seventh graders tend to give more reasons (usually thre to five), as well as more elaborated responses to this question. For example one said s/he ate "for energy...because of all the vitamins and stuff in it... It makes you like active so all the time you don't want to just sit down on the sidewalk." Another said, "So you can be healthy and you don't just dehydrate... It (food) supplies the necessary things for the body to live on. The cells need food."

There are age level differences in the reasons given for eating. Most frequently mentioned by kindergartners was growth; by third graders, energy; by seventh graders, hunger. Third and seventh graders are alike in that life and strength are ranked second and third, while, for kindergartners, strength and hunger are.

Thus, the influence of parents and/or school seems to be predominant here, even for the youngest, and perhaps, the desire the give the "right" answers. At the same time, the most frequently mentioned reason at each age level--growth for the youngest, energy for the third graders, and (aside from hunger) being alive for the seventh graders--may have psychological meaning for each of these stages of development and may, therefore, turn out to be age-related, in a larger sample.

g. Comprehensiveness of overall concept of the digestive-eliminative-assimilative process.

The nine summary statements presented in Table 16 include the most salient elements that characterize the responses, ranging from the least to the most differentiated and sophisticated. Summary 1 presents the most elementary, naive view of these processes.[1] The most important elements in this view are underlined. In the remaining eight summaries, the elements which are added are underlined to emphasize the differences. These additional elements are given more or less in age-related order (from kindergarten to seventh grade) as they occur in this sample. Thus, the sequence indicates increasing complexity and differentiation of concept.[2]

Table 16

SUMMARIES OF OVERALL CONCEPTS OF THE DIGESTIVE-ELIMINATIVE-ASSIMILATIVE PROCESS

1. The food goes to the stomach and stays there (in some cases going through the pipe/esophagus on the way). In some cases it undergoes a change in size. It may be used by the body for growth, strength, health, to stay alive, etc.

2. The food goes to the stomach and stays there (in some cases going through the pipe/esophagus on the way). It undergoes a change in size, goes to various parts of the body, and is used by the body for growth, etc.

3. The food goes to one or more parts of the gastrointestinal tract, where it undergoes changes in size and/or consistency, as a result of mechanical/muscular and/or dissolving action. It is eliminated from the body by defecation and (in most cases) is used by the body for growth, etc.

4. The food goes to one of more parts of the gastrointestinal tract, where it undergoes changes in size and/or consistency as the result of mechanical/muscular and/or dissolving action. It either leaves the body by vomiting or is

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1 In order to limit the number of Summaries, each Summary contains one or more elements which may not have been included by all the subjects who expressed the overall concept. (See Table 17) Here, this is indicated by "in some" or "most" cases or "may" or "usually."

2 Except for Summary 4, which is mixed--advanced in one respect and retrogressive in another.

not eliminated at all. It is distributed in the bloodstream to various parts of the body and is used by the body for growth, etc.[1]

5. Food goes to one or more parts of the gastrointestinal tract where it undergoes changes in size and/or consistency as the result of mechanical/muscular and/or dissolving action. It is eliminated from the body by defecation. It goes to various parts of the body and, in most cases, is used by the body for growth, etc. (Although no new element is added, this differs from all previous and subsequent versions.)

6. Food goes to one or more parts of the grastroinestinal tract where it undergoes changes in size and/or consistency as the result of mechanical/muscular and/or dissolving action. It is eliminated from the body by defecation. It is distributed in the bloodstream to various parts of the body, and in almost all cases, is used by the body for growth, etc.

7. Food goes to one or more parts of the gastrointestinal tract where it undergoes changes in size and/or consistency as the result of mechanical/muscular and/or dissolving action. The nutrients are separated from waste. Elimination (of what is usually called "waste") takes place by defecation. The nutrients are distributed in the bloodstream to various parts of the body where (in almost all cases) they are used by the body for growth, etc.

8. Food goes to one or more parts of the gastrointestinal tract where it undergoes changes in size and/or consistency as the result of mechanical/muscular or dissolving action and where chemical[2] agents may produce changes, usually in size and/or consistency. The nutrients are separated from waste. Elimination takes place by defecation. The nutrients are distributed in the bloodstream to various parts of the body where (in almost all cases) they are used by the body

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[1] Distribution in the bloodstream is advanced. It does not occur again until Summary 6.

[2] "Chemical" is used very broadly here to include the mention of "digestive" juices/acids/chemicals and pancreatic or gastric juices.

for growth, etc.

9. Food goes to one or more parts of the gastrointestinal tract where it undergoes changes in size and/or consistency as the result of mechanical/nuscular or dissolving action and where chemical agents may produce changes, usually in size and/or consistency. The nutrients are separated from waste. Elimination takes place by defecation. The transformed nutrients are distributed in the bloodstream to various parts of the body and are used for the creation of new cells (growth) or oxidized in the cells to produce energy.

Table 17 presents the number and percentage of subjects at each age level whose overall concept fits the Summary descriptions given in Table 16.[1]

Table 17
COMPREHENSIVENESS OF OVERALL CONCEPT OF DIGESTIVE-ELIMINATIVE-ASSIMILATIVE PROCESS

Summary #	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	%	Girls	Boys	Total	%	Girls	Boys	Total	%
1	2	1	3	15	0	1	1	5	0	0	0	0
2	2	1	3	15	0	0	0	0	0	0	0	0
3	5	2	7	35	0	1	1	5	1	0	1	5
4	0	2	2	10	2	2	4	20	0	0	0	0
5	1	1	2	10	3	0	3	15	0	0	0	0
6	0	3	3	15	2	5	7	35	0	0	0	0
7	0	0	0	0	3	1	4	20	4	2	6	29
8	0	0	0	0	0	0	0	0	4	5	9	43
9	0	0	0	0	0	0	0	0	2	3	5	24
Total	10	10	20	100	10	10	20	100	11	10	21	101

Overall concepts held by kindergarten subjects range over a broad area from the most naive and undifferentiated (Summary 1, 15%) to a rather sophisticated and complex view (Summary 6, 15%). The average (median) overall concept (Summary 3,

[1] See footnote 1, p. 41.

held by 35%), includes changes in the size and/or consistency of the food as a result of mechanical/muscular and/or dissolving action in one or more parts of the gastrointestinal tract, elimination of solid waste, and the utilization of food for growth, health, etc.

The overall concepts held by third graders cover an equally large range, from the most naive (Summary 1, 5%) to an even more sophisticated view than that of the kindergartners (Summary 7, 20%). The median overall concept (Summary 6, held by 35%) is that of the most sophisticated kindergartners. This adds to the average view of kindergartners the distribution of food via the bloodstream to various parts of the body.

The seventh graders differ from the younger subjects in that the range of concepts held is much smaller. The median overall concept (Summary 8, held by 43%) adds to the average concept of the third graders changes in food by means of chemical agents, the separation of nutrients from waste and distribution of nutrients to the body via the bloodstream. The most sophisticated and differentiated concept (Summary 9, held by 24%) includes awareness that nutrients are transformed into new cells and energy.

Summary of Age Group Patterns of Similarity and Difference. (1) There is an increase in homogeneity of overall concepts with age. The kindergarten subjects show the greatest variability in overall concepts and the seventh graders show the greatest degree of homogeneity of overall concepts. (2) The third graders are similar to the kindergartners in their overall view of the digestive-eliminative-assimilative process in that 85% of the kindergarten subjects and 80% of the third graders express the views delineated in five of the Summaries (#1, 3, 4, 5, and 6). They also show some of the same contradictions and confusions which are inherent in the concepts of some kindergarten subjects, namely:

(a) All the food stays in the stomach. At the same time, it helps make you bigger, stronger, etc. (Summary 1)

(b) No connection between intake and outgo is mentioned (except, in a few cases, via vomiting) as though it were possible for all the food that is eaten day after day to remain in the body. (Summaries 1, 4)

(c) Food is described as going to various parts of the body by some subjects, although they have no idea of how it gets there.

They differ, however, in that a greater proportion of third grade subjects (35%) than of kindergarten subjects (15%, express the most sophisticated overall view (Summary 6). In addition, one-fifth of the third graders express the overall concept as enunciated in Summary 7. (3) Although approximately the same proportion of third graders (20%) and seventh graders (29%) describe the digestive-eliminative-assimilative process as expressed in Summary 7, all but one of the remaining seventh graders (67%) are alone with respect to Summaries 8 and 9. Thus, not only are the seventh graders' concepts the most comprehensive, but also they are the only ones who include the assimilative process.

However, differences between third and seventh graders are not so great as the figures indicate with regard to knowledge and understanding. Although seventh graders are cognizant (and the third graders are not) of chemical agents (digestive juices, etc.) only a few are aware that the transformed nutrients are used for the creation of new cells, and only one, that they are oxidized in the cells to produce energy.

h. Effects of not eating.

Kindergarten subjects. In response to the question, "What would happen if you stopped eating altogether?" 55% of the kindergarten children did not mention dying at all. (Table 18) Many of them (67%) said such things as: you wouldn't get strong, healthy, bigger, grow up (would stay little). Other responses appear to be expressions of their own experience: "If you don't eat, you'll be hungry." "Your belly would growl and pound." And one involves the confusion of size with age--"You would get smaller--turn into a baby."

Table 18
EFFECTS OF NOT EATING

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	%	Girls	Boys	Total	%	Girls	Boys	Total	%
You would die	1	5	6	30	7	9	16	80	10	10	20	95
You might (or probably) die	2	0	2	10	1	0	1	5	1	0	1	5
No mention of dying	6	5	11	55	2	1	3	15	0	0	0	0
No answer	1	0	1	5	0	0	0	0	0	0	0	0
Total	10	10	20	100	10	10	20	100	11	10	21	100

Third Graders. Most third graders (85%) mentioned death when asked, "What would happen if you stopped eating?" (Table 18) Those who did not (15%) mentioned such things as getting weaker, unable to move or walk, getting skinnier.

Seventh Graders. All the seventh graders mentioned death when asked, "What would happen if you stopped eating altogether?" (Table 18) In addition, many described processes that preceded death, e.g., decay or dehydration of the body, getting skinnier. The most detailed description of the process involved deterioration of the body "because you don't feed the right nutrition to the parts of your body and then the bones won't be strong enough and they may break."

The Interview--Summary of Results. There are age level differences with respect to knowledge of facts (not necessarily accurate) about the functioning of the digestive system as follows:

(1) An increase with age in knowledge of where the food goes after it is swallowed and the sequence in which it moves through the organs of the gastrointestinal tract.

(2) An increase from kindergarten to seventh grade with respect to the number of major digestive organs and body parts mentioned; the number of other organs and body parts related to the digestion and distribution of food and elimination of waste mentioned; and from kindergarten to third grade only, in the number of organs not related to the digestive system.

(3) The major age level difference with regard to processes by which food moves through the gastrointestinal tract is that only seventh graders mention muscles or contractions. There is an increase from kindergarten to third grade in the mention of slipping/sliding. Virtually all subjects mentioned swallowing.

(4) There is an increase with age with respect both to the number of organs and body parts in which digestive processes take place and the number and kinds of processes that are mentioned. The biggest age difference is in the mention of chemical processes by seventh graders only.

(5) There is an increase between kindergarten and third grade only in the percentage of those who say that food is distributed to the body. The percentage of third and seventh graders is virtually the same.

(6) There is an increase with age in mention of movement of food/nutrients into the bloodstream.

(7) There is an increase with age in the percentage of those who say that food/nutrients is in the form of a liquid when it is in the bloodstream; and in the awareness that the bloodstream is the route by which food is transported to the body.

(8) There are age level differences in the most frequent reason given for eating: kindergarten, growth; third grade, energy; and seventh grade, hunger.

(9) There is an increase with age in homogeneity of overall concepts of the digestive-eliminative-assimilative process. The degree of variability in overall concepts is greatest among kindergarten subjects and least among seven graders.

(10) There is an increase with age in awareness that cessation of eating results in death.

There are virtually no sex differences with regard to the above.

2. Conceptual Framework

The leading questions in the interview were aimed at finding out what concepts the subjects had of the various aspects of the digestive-eliminative-assimilative system. The focus was on what happens to food from intake to outgo, whether or not and how it is distributed to and assimilated by the body; why food is necessary; and the effects of cessation of eating.

Other questions were designed to stimulate the subjects to give explanations and also to find out what kinds of data and cues the subjects used when asked for

explanations of their responses; e.g., whether they made use of what they had been taught (formally or informally), whether they based their explanations on their own experiences, or their imaginations. The kinds of explanations they gave were expected to provide clues to the nature of their understanding of the digestive system and the assimilation of food.

There are only a few questions which elicited enough explanatory responses to make it possible to discern patterns of responses.[1] There are four areas:

a. Explanations given in relation to the reasons for eating;

b. Explanations of what makes food change in color and size/consistency during digestion;

c. Explanations of why food does not go to specific parts of the body; and

d. Nature of the understanding of the transformation of matter into energy and other matter

a. Explanations Related to the Reasons for Eating. The question, "Why do you eat?" produced a variety of responses and is the richest source of explanations. Since the content of the responses varied from subject to subject, the content of the explanations of these responses also varied. The kinds of explanations covered are: how eating keeps you alive, makes you strong and/or healthy, gives you energy, and also how you know you are growing and how you know you are hungry.

Because of the character of the responses and some differences in questions to kindergarten subjects, it seems more appropriate to reverse the order of presentation, starting with the oldest instead of the youngest.

(1) How food keeps you alive, makes you strong, healthy, and helps you grow

Seventh Graders. Eighty-six percent of the seventh graders were asked, "How does

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[1] Not all subjects were asked these questions. Questions were sometimes omitted for the younger subjects because they were unable to sustain their attention, for very talkative ones, or because of the pressure of time.

food keep you alive?" or whichever question was relevant to their response. One-third of these attempted to use one or more physiological facts to explain how the food does whatever they said it did. (Table 19) Almost all mentioned "cells"--strengthening of, reproduction of, growth of. For example, "The food helps the cells of your body...It helps them grow...that's how you grow--the cells multiply." Others introduced the heart and its role, e.g., "It (food) gives your heart energy to pump and so the blood goes around and gives your other parts of the body oxygen so you can move, you can eat." One of these also used an analogy, "...the body, like, burns it up...It's like a fuel, kind of." Some responses regarding how food keeps you alive were not responses to the question, i.e., they would say that food makes you strong or healthy; and some were non-explanatory, e.g., the cells would "just die off" (if you didn't eat).

The largest proportion of responses (44%) had to do with the need for specified nutritional elements. For example, "'Cause of the vitamins, the minerals and the calcium, the iron, too, keep my body going, running."

Twenty-eight percent merely described the effects of eating or not eating. For example, "Like breakfast. Breakfast is one of your main meals and you're supposed to eat because..it makes you..not like you're dead in the morning...And you need it in your body. You need that first bit of food."

Table 19
HOW EATING KEEPS YOU ALIVE, MAKES YOU STRONG, HEALTHY, AND HELPS YOU GROW--SEVENTH GRADE

Category[1]	Girls (N=8)	Boys (N=10)	Total (N=18)[2]	Percent
Use of physiological information	3	3	6	33
Analogy	0	1	1	6
Need for specified components of food	3	5	8	44
Effects of eating or not eating	0	5	5	28

1. These are overlapping categories. Percentages do not total 100%.
2. Three subjects were not asked this question.

Although their responses were often based on facts which were more or less correct and relevant, seventh grade subjects did not explain the processes by which the effects they mentioned were achieved. Sometimes their responses were vague and superficial. For the most part, their responses indicated that they really did not understand what took place, in physiological terms.

Third Graders. The third graders' responses to the questions, "How does the food keep you alive?" etc. are so varied that they are difficult to categorize. Thus, there are often as many variations within categories as there are subjects--particularly the first two categories.

Of the nine-tenths who were asked one of these questions, 39% gave some version, usually more specific, of "The body needs food." (Table 20) The most specific, in several ways, is the following: "Because it is good for your muscles. When you get muscles that means that...you're getting stronger because you're eating more foods...and then..say you're a weak guy, you can lift up heavy things because you have been eating meat...The meat goes to your muscles and it helps you lift things, to do things that you may not have done before." Or, "It (food) feeds the brain. It makes it (the heart) pump."

Table 20

HOW EATING KEEPS YOU ALIVE, MAKES YOU STRONG, HEALTHY, AND HELPS YOU GROW--THIRD GRADE

Category[1]	Girls (N=9)	Boys (N=9)	Total (N=18)[2]	Percent
Body needs food[3]	6	1	7	39
Food goes to/travels through body--to all or specific parts	5	0	5	28
Food turns into skin, bones, and/or blood	1	1	2	11
Calories give you energy	1	0	1	6
Components of food mentioned	0	1	1	6
Repetition of original statement	0	1	1	6
"Don't know"	1	5	6	33

1. These are overlapping categories. Percentages do not total 100%.

2. Two subjects were not asked this question.

3. Includes general statement or one or all general or specific part(s) of the body, food(s) or function(s).

Twenty-eight percent of the third graders said that food goes to/travels through the body--in some cases, to all the body--"It travels all over your body in those tubes"--and, in some, to specific parts--"'Cause if you eat a fruit... it goes to your arms, and then, like, it gives you more strength."

Another said that food gives you calories and calories give you energy. "I eat an apple and the calories, they get, you know, so you can move." ("Calory?") "Fat...if I eat now, I'll have enough energy for three hours of reading, of playing, and many things." Or, more sophisticatedly, "Well, maybe some (food) stay in one place and then it travels to another place in the body and then it stays in it and it gets into the stuff...The things that are at that place...it will turn into this stuff that's there." (?) "Blood, skin, bones," These last two quotes indicate that these subjects have some idea, primitive as it is, that food is somehow turned into matter or energy.

Because many more boys than girls said they did not know, more girls gave substantive responses. Many more girls (N=6) than boys (N=1) said that the body needs food, either simply or more complexly. Five girls and no boys said at the food travels to your body (all or specific parts) in order to keep you alive, etc. In addition, many of the girls' responses were fairly detailed, while the three boys who did answer the question did so in short, simple statements.

Kindergarten Subjects. All the kindergartners were asked either how the food helped them grow, stay alive, etc., or where appropriate, "How does the food get

to where it's supposed to be in order to keep you alive, etc."[1, 2] Many more questions were asked of them than of the older subjects in order to stimulate them to respond. Seventy percent responded substantively; the rest said they didn't know. (Table 21) One-fifth said that food had vitamins, but gave no indication of how that made them strong, etc. One-tenth said that food builds up the muscles. When asked how food built up the muscles, one said, "It gives you energy," and, when questioned further, said her mother told her it would make her strong. The other said she didn't know.

In response to the question, "How does the food get to where it's supposed to be in order to make you healthy, etc.," one-fourth said that it travels around or goes to your body, the muscles or the stomach. When asked how food stopped hunger, one gave a quasi-animistic response,[3] "When I eat food...the body like chew(s) it up and then it takes a rest...And then, when it stops resting, it gets up and starts growling for more."[4] Two gave idiosyncratic responses. One described a TV show--"In a show there was a little man." (?) "He's small." (I.: "What has that got to do with eating?") "He didn't eat." That is, if you don't eat, you don't grow. The other, when asked how the food gets to where it has to go in order for him to grow, said, "It goes to your brain." (?) "'Cause there may not be gravity in your mouth." (I.: "Does it go any place else?") "The gravity makes it go down."

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1 As a result, some children who had not previously said anything about the food going to parts of the body, revealed that they knew this and even, in some cases, that it went via the bloodstream.

2 Because these children were so young, the order of questions was changed to suit individual needs. Most of the children who had said they ate in order to grow or because they were hungry were asked how they knew they were hungry or growing before they were asked how food helped them grow, or how it stops hunger.

3 Defined for the purpose of this study as "couched in animistic terms." It does not necessarily imply that the subject conceives of the stomach "as living and endowed with intentions." (Piaget, 1967, p. 26)

4 The word "like" in this quote is not taken to mean "similar," since it is used by all subjects indiscriminately, with the current non-meaning.

(?) "To your stomach."

Most of their responses are, in some way or other, relevant to the questions asked. But no connections are made, even when further questions are asked, and no explanations given.

Table 21

HOW EATING KEEPS YOU ALIVE, MAKES YOU STRONG, HEALTHY AND HELPS YOU GROW--KINDERGARTEN

Category[1]	Girls (N=10)	Boys (N=10)	Total (N=20)	Percent
Components of Food (Vitamins)	3	1	4	20
Food travels around and/or goes to your body, or to specific parts	1	4	5	25
Food builds up the muscles	1	1	2	10
Quasi-animistic	0	1	1	5
Other	1	2	3	15
"Don't know"	4	2	6	30

1. These are overlapping categories. Percentages do not total 100%.

It is clear from their responses that children of all ages were given information relevant to these questions, at school and/or at home. The seventh graders learned about the digestive system in school. From their responses and what they told us, the third graders seem to have learned something about nutrition (what they call "health") in schcol. The kindergartners were apparently told something about the important components of food and that the food goes to various parts of the body.

Thus, the seventh graders are more knowledgeable. But even those who gave responses based on physiological information, give little indication that they understand the complexities of the assimilative process. Their responses are also more homogeneous. The third graders' responses are more varied. They know more than the kindergartners, but their explanations tend to be literal interpretations

of what they have been told. After much probing, the kindergartners tell you what they know which is, necessarily, very little, but make no effort to explain what they said. Possibly because of the meagreness of their knowledge, their responses are more homogeneous than those of the third graders.

(2) How you know you're hungry

When asked, "How do you know you're hungry?" the responses were, of necessity, of a different order from those described above.

Seventh Graders. Of the twelve seventh graders who were asked, almost all (92%) described intra-body sensations (usually sounds or pains in the stomach). (Table 22) For example, "pains in your stomach...your stomach growling...your throat is dry." One-third gave responses which might be considered quasi-animistic. The stomach, the brain and, in one case, nerves, are usually cited as parts of the body that "tell" them they're hungry. For example, "...like nerves...it's, like, they tell you you're hungry...the nerves tell you that."

Only one seventh grader mentioned a physiological fact, "I think it's (i.e., you know you're hungry) after whatever food you've eaten finally finished being digested and there is no food there" and then added, quasi-animistically, "...and it's (i.e., your empty stomach) looking around for food and there is nothing there, so it's telling your brain you're supposed to eat."

One response involved an inference from a general, non-food related feeling. "Sometimes you get tired and you can tell that you need some food." And another subject is aware of hunger because of a vague "urge for something to eat."

Table 22

HOW YOU KNOW YOU'RE HUNGRY--SEVENTH GRADE

Category[1]	Girls (N=5)	Boys (N=7)	Total	Percent
Intra-body sensations	5	6	11	92
Quasi-animistic	1	3	4	33
Use of physiological information	0	1	1	8
Inference	1	0	1	8
Vague	0	1	1	8

1. These are overlapping categories. Percentages total more than 100%.

Third Graders. Only four third graders said they ate because they were hungry. All of these mentioned intra-body sensations as indicators that they knew they were hungry--your stomach growls, you get a stomach-ache, your stomach feels empty, you don't feel well. One child couched his reply in quasi-animistic terms--"It (the "hungriness) gives messages to the brain" ("Where?") "Around your stomach...it growls like...the growling gives messages right to the brain and then it gives messages to my mouth, 'I'm hungry, I'm hungry.'"

Kindergarten Subjects. Like the third graders and most of the seventh graders, all but one of the seven kindergarten children who were asked mentioned intra-body sensations--stomach growls, hurts, feels empty. One said, "Because I have a funny feeling in my mouth." (?) "Like kind of a watery feeling...like it's water in there." Another gave a more complex response, "When I'm in the house and leaving for school and I haven't had any breakfast." (?) "Sometimes I run so fast that I get hungry." (How does it feel?) "Like a hole." (?) "'Cause when I run my brain gets hungry."

The most frequent, and to be expected, response at all age levels is in terms of intra-body sensations. There appears to be an inordinate amount of awareness of "growling" sounds in the stomach, at all age levels. One wonders whether there

actually is so much or if this is something they were told. It is interesting also that more seventh graders gave quasi-animistic responses than younger subjects, since these are on a more more primitive level. We have noway of knowing whether these responses stem from their own quasi-animistic thinking or from their teachers' use of quasi-animistic explanations, as well as analogies, to clarify difficult concepts. On the other hand, they may be literal interpretations of what they were told.

(3) How you know you're growing

Seventh Graders. Of the seven seventh graders who said that eating makes you grow, 57% cited perceptual cues when asked, "How do you know you're growing?" (Table 23) For example, "Well, mostly, you just get closer to your parents' heads," and "Yeah, your clothes."

Twenty-nine percent indicated that being measured was their source. "'Cause you can tell when you measure yourself...and, if you get on the scale, you can tell if you're getting fatter."

Two subjects (29%) responded by citing biological facts, e.g., "You know your cells are reproducing." One subject described growth in historical terms--the relationship between age and growth. "First you're a baby and then a couple of years later, you're bigger and walk and your legs get stronger so you can walk."

Table 23
HOW YOU KNOW YOU'RE GROWING--SEVENTH GRADE

Category[1]	Girls (N=5)	Boys (N=2)	Total (N=7)	Percent
Perceptual cues	2	2	4	57
By measurement	2	0	2	29
Use of biological information	1	1	2	29
Relationship of growth to age	0	1	1	14

1. There are overlapping categories. Percentages do not total 100%.

It is surprising that only two mentioned measurement of height or weight as the obvious way to find out. It is possible that, since the question was phrased in personal terms, most of them just described perceptual cues, even if they were aware that measurement was a more accurate way of finding out.

Third Graders. Only three third graders said that food made them grow. Of these, only two were asked, "How do you know you're growing?" One said, "You don't." The other said, "I measured myself once. My dad gets out the tape measure...well, we have a piece of paper that says how many inches that I am in one month and then the next one." ("How do you know you're growing?") "I see how many, how much (more?) inches are than last time."

Kindergarten Subjects. Of the ten subjects, (4 girls and 6 boys) who were asked, "How do you know that you're growing?" only one said he didn't know. The others gave a variety of answers (sometimes more than one). Four said that you grow while you sleep or "from" your sleep. Three of the four mentioned eating in conjunction with sleeping, and one also said her father had told her that. "'Cause when you are sleeping and you eat, you grow up." (?) "My daddy told me when you sleep you grow."

Three mentioned perceptual cues, e.g., get bigger, taller, stomach gets bigger. One of these also mentioned weighing herself; another related getting taller to age. "You're getting tall." (?) "When someone was small and then you, then he grows up, then you can tell."

Two mentioned measurement. "I weigh myself." (?) "Because shows different numbers." ("Bigger or smaller?") "Sometimes big and sometimes small." ("Taller?") "I only had that at my doctor's."

One first said he didn't know and, when questioned further, said, "I can see it in my (younger) sister." (?) "That you're bigger than the other one." He also said he always weighs the same but more than his sister. Thus, he infers growth from the fact that he is taller and weighs more than his sister.

Despite their knowledge, the responses of most of the seventh graders are not too different from those of the younger subjects. Many mention perceptual cues and measurement at all age levels. One seventh grader and one kindergartner mentioned the relationship between growth and age. The main difference between the kindergartner and the other subjects is the kindergartner's view that sleeping, often in conjunction with eating, is the source of growth. This sounds very much like a misinterpretation of the meaning of what they were told by their parents. The main difference between the seventh graders and the other subjects is that a couple of seventh graders cite biological information.

b. Explanations of what makes food change in color and consistency/size.

As the children described the progress of food from the mouth to the stomach, several questions were asked. Among them were questions concerning the color and consistency of the specific food they were talking about, by the time it reached the stomach. All were then asked to explain the reasons for whatever they had said.

(1) Color of food.

The percentage of subjects who gave explanations of why the specific food they had been talking about was the color they said it was when it arrived in the stomach increases somewhat with age: 30% kindergarten, 40% third grade, and 52% seventh grade. (Table 24)

Two-thirds of the kindergarten subjects who gave explanations said that the color was due to the effect of blood on the food, while one-quarter of the third graders who gave explanations, but no seventh graders, explained it this way. (Table 24) For example, like most of the kindergartners who explained it this way, one said, "It changes to red because...the blood gets on the food." One of the third graders said that the color of the food remained the same, but it looked red "because the blood hits it" as it goes to the stomach.

Some explained the color in terms of some sort of mixture--of the food and saliva, of various foods and liquids or of the food itself. No kindergarten subjects gave this explanation, but three-eighths of the third graders and 64% of the seventh graders did. The third graders attributed the color to a mixture of food and saliva and also a mixture of the food itself. The seventh graders gave all three kinds of mixtures as explanations of the color. For example, a seventh grader said, "'Cause there is a lot of other foods also in the body that are mixed together makes it a dark color. There is always some food in the stomach...and, when something else goes down, it gets mixed together."

Other kindergartners gave three other explanations, one for each--the action of the stomach, saliva and chewing. Other third graders explained that it was the color of the food itself (i.e., no change had taken place) and one attributed it to germs and gave a very confused explanation. "I think it gets darker...'cause you know how germs can't see." Like the kindergartners, seventh graders also attributed the change in color to saliva and chewing of the food, and two attributed it to dissolving of the food.

Table 24
THE COLOR OF FOOD IN THE STOMACH

Category[1]	Kindergarten (N=6)				Third Grade (N=8)				Seventh Grade (N=11)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Effect of blood	1	3	4	67	1	1	2	25	0	0	0	0
Mixture:	0	0	0	0	2	1	3	38	6	1	7	64
of food and saliva	0	0	0	0	0	1	1	13	3	0	3	27
of various food and liquid	0	0	0	0	0	0	0	0	2	1	3	27
of the food itself	0	0	0	0	2	0	2	25	1	0	1	9
Action of stomach	1	0	1	17	0	0	0	0	0	0	0	0
Saliva	0	1	1	17	0	0	0	0	0	1	1	9
Dissolving of food	0	0	0	0	0	0	0	0	0	2	2	18
Chewing	0	1	1	17	0	0	0	0	0	1	1	9
Germs	0	0	0	0	1	0	1	13	0	0	0	0
Color of the food itself	0	0	0	0	1	1	2	25	0	0	0	0

1. These are overlapping categories. Percentages do not total 100%.

Since the children had no way of knowing what color the food would be, they were not only forced to guess, but also to figure out how the change could have taken place, or why there had not been any change.[1]

There are age-related differences in the explanations given by the subjects. Most of the explanations of the seventh graders and some of the explanations of the kindergarten and third grade subjects appear to be based on what they knew about digestive processes, e.g., the mixture of food and saliva. A large proportion of the responses of the kindergarten subjects, however, and a smaller proportion of those of the third graders (the effects of blood, and of "germs") seem to be the result of confusion about what they had been told, fantasies or phenomenistic thinking.

(2) Change in consistency/size of food

Only a few subjects attempted to explain the reason for change of consistency/size of food when it was in the stomach. Of the two kindergarten subjects who gave explanations, one said it was the result of the stomach "vibrating." The other explained, "'Cause one day, like, I was running and I got cut in the leg here. And then I scratched and I could see the meat." After further questioning, he said that what he saw was what food was like in the stomach. The one third grader who responded gave a long and complicated explanation. She said, in part, "'Cause some is going down slow...like slow medium, and the other food is going faster and then (they) get pushed together," and, therefore, into bigger pieces. When asked how she knew that, she replied, "Why, is there any other way the (food) can get bigger?"

Three of the six seventh graders who responded, ascribed the change in consistency to saliva or digestive juices. Another, using perceptual cues and awareness of his own action, said the food was "like little balls...soft...when

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[1] No one mentioned that they knew because they saw it when they vomited.

you chew it. Then your tongue kind of rolls them back and then you swallow them and it's kind of little balls that are soft." The other explanations had to do with the effect on food as it moves through the esophagus and the fact that all the food rests "in one spot and all get together."

Apparently, at all age levels, the subjects had more difficulty explaining the reasons for change in consistency or size of the food by the time it reached the stomach then they did for the color of the food. Even some of the seventh graders appeared less able to use what they knew than they were in their explanation of the color of food.

c. Explanation of why food doesn't go to specific parts of the body.

When describing the parts of the body to which the food goes, some subjects mentioned specific parts of the body to which food did not go (p. 33). Some of these (kindergarten, 3; third grade, 4; and seventh grade, 5) explained, either spontaneously or after questioning, why the food did not go to these parts. The reasons they gave implied that none of them understood how the food was distributed to the body, that is, there was no understanding of physiological functioning, in this respect.

The largest number (three kindergarten, two third grade and three seventh grade subjects) gave responses based on physical characteristics of parts of the body. For example, one kindergarten child said the food could not go to the shoulders because "there isn't too much room in there." Another said the food goes only as far down in the legs as the knees "'Cause this knee is blocking it." A third grader said it doesn't go to "your fingernails...'cause they're solid." Another gave as one reason the food does not go to your nose, "Because your nose doesn't need meat because it had that bone right there. The seventh graders' reasons were no more sophisticated than those of the younger subjects. One said, "I just think it doesn't go to the brain...because when we studied the brain...

it was like there was no room for anything to go up there." Another said, "Probably the ears, 'cause it's cartilage...the nose...same cartilage."

Three subjects (one kindergarten and two third grade) gave explanations based on the belief that food (or blood) can go in only one direction. The third graders said that the food could not go to specific parts of the body (brain, nose, throat) "because you swallow down, not up" and "Cause it--your throat swallows, it pushes it down so it just goes to the sides, to your arms." The kindergartner's statement that food cannot go to your head--"Only your blood does when you're standing on your head"--seems to imply in addition, that only one substance, blood, can go to your head.

One seventh grader gave two kinds of explanations. One was based on need--"I don't think your arm needs that much." She also said that the blood with food in it doesn't go to the bones "because the bones make the blood in the marrow." The latter is based on a physiological fact, but is used incorrectly. Another seventh grader said, "I don't think it goes into the brain"...because "like, the brain tells it where to go." That is, the brain is the director of the activities. The last two explanations seem to be based on the premise of exclusivity, i.e., the producer or director cannot also be a recipient.

One third grader, apparently connecting blood in the nose with nose bleeds, explained, "There's no blood cells in your blood...it only comes around to the head...and it won't go any further or else it would come out of your nose."

The kinds of thinking, e.g., phenomenistic, on which these explanations are based result in misconceptions of physiological functioning. It is interesting that as many as five seventh graders give explanations based on these particular misconceptions, since all but one seventh grader had said that food was distributed to all parts of the body, and all but two, that it was distributed via the bloodstream.

d. Transformation of food into energy and other matter.

The ultimate purpose of the digestion and assimilation of food is its transformation into other matter (repair, replacement and creation of cells) and into energy. Many subjects, at all ages, mentioned growth and energy as the reasons for eating. Their responses to questioning about how food makes you grow and gives you energy give us some inkling of the prevalance and quality of understanding of these transformations, at each age level.

Approximately half the kindergartners said that food makes you bigger, taller. In response to the question, "How does it make you bigger/taller?" only one explained. She said that, if she weighed herself, she would know that she was growing. This suggests that she might have had some idea that the food she ate became part of her, but knew nothing about the process. The rest of the subjects who mentioned growth either gave irrelevant answers or, because of obvious ignorance, were not asked how food would make them grow. The one kindergartner who mentioned energy as a reason for eating knew nothing but the word itself.

The two third graders who mentioned growing as a reason for eating said that food goes in various parts of the body and "turns into the stuff that's there--blood, skin, bones." But neither had any notion of how food makes you grow. Although about half the third graders mentioned energy as a reason for eating, only a few tried to explain what energy was: "Like power." "Energy makes things run. Like cars, all kinds of machines and your body. Cars need gas and the body needs food." Another said there were different kinds of energy--"The kind in your body when you eat the food and the kind that you get from the power plant." Most of those who mentioned energy seemed to understand that there is some relationship between food and activity, for example, that energy makes it possible for you to run and, even, to think faster. But none seemed to have any idea how food is transformed into energy or into other matter.

Of the seventh graders who mentioned growth as a reason for eating, a few said that food makes cells multiply or reproduce. For example, "Other cells use it (food)...to make more cells and that makes him (sic) bigger." Another said that blood cells contain nutrients. "The body feeds off it (the blood)...It produces more blood cells." None of them, however, knew how this transformation occurs. With respect to the transformation of food into energy, only one of those who mentioned energy as a reason for eating attempted to explain how this transformation takes place." "'Cause when it is broken down--the nutrients and stuff--the body, like, burns them up...It's like a fuel, kind of...and when it gets into the blood, it goes around all the places and...it goes into the cells, I guess, and it makes them do what they're supposed to."

Thus, none of the subjects, from kindergarten through seventh grade, really understood how food was converted into the substance of the body, and only one had an idea of how it was converted into energy.

Summary

Our exploration of the nature of the explanations given by the subjects does provide some insight into the extent to which the kindergarten, third grade and seventh grade subjects understand the digestive-distributive-assimilative processes and the principles underlying them. Although some age level differences are apparent, the understanding of even the oldest and most knowledgeable subjects is limited. In fact, perceptual cues, including intra-body sensations, are used as the basis for explanations very frequently at all ages (sometimes because of the nature of the questions asked), as are the needs of the body. Younger subjects often repeat what they have been told by adults, generally without understanding the meaning, and thus sometimes give literal interpretations to remarks which are not meant to be taken literally. Most of their explanations are non-explanations.

Although the seventh graders do, on occasion, apply the information they have, when explaining, they do not always make use of the physiological information

they have acquired. Perceptual cues are more accessible and tend to be used, although sometimes incorrectly. The nature of many of their explanations suggests that their focus is on information, rather than on understanding the processes or principles of physiological functioning.

B. The Digestive Process Drawing (DPD)

The drawing of an internal body system was probably a completely new experience for the subjects except for a large number of seventh graders (57%) who said they had seen (and may even have been asked to reproduce) diagrams of the gastrointestinal tract. For this reason, and because it was a free drawing (i.e., no body outline was presented), there is a great deal of variation among individual subjects in the way they depicted the digestive process, despite the fact that the main content of the drawing is necessarily limited to the organs of the gastrointestinal tract. The subjects were also asked to show where the food goes, how it moves, what it looks like, and any changes in it that take place.

The drawings shall be described in the following ways:

1. Organs and body parts, related and unrelated to the digestive-eliminative-distributive processes.
   a. major organs and body parts of the gastrointestinal tract;
   b. other organs and body parts related to the digestive-eliminative-distributive system (including blood vessels);
   c. other organs and body parts not related to the digestive-eliminative-distributive system.
2. Graphic indication of food--where it goes, movement of food and changes in it.
   a. food in various parts of the body (not in the bloodstream).
3. Body outline.
4. Expressive characteristics.

1. Organs and body parts related and unrelated to digestive-eliminative-distributive processes.

a. Major organs of the gastrointestinal tract

The number of major organs included in the drawings by one or more subjects in each age group increases with age, from 4 (kindergarten) to 5 (third grade) to 10 (seventh grade). (Table 25) The kindergarten subjects included the mouth, the pipe/esophagus, stomach and liver. In addition to those included by the kindergartners (except for the liver), the third graders also drew the intestines (undifferentiated) or the small and large intestines. To those included by the third graders, the seventh graders added the duodenum, the gall bladder, the liver, the pancreas and the rectum.

The number depicted by 50% or more of the subjects at each age level also increases with age--2 (kindergarten), 3 (third grade) and 5 (seventh grade) out of a possible total of 10. Almost all (95%) of the kindergarten subjects drew some sort of representation of the stomach, in a variety of different ways. Slightly more than half (55%) drew a mouth. All the third graders drew the stomach; 85%, a pipe/tube representing the esophagus; and 50%, the mouth. Ninety-five percent of the seventh graders drew the stomach; 90%, a pipe/tube representing the esophagus; 85%, the mouth; and the small and large intestines (71% for each). One seventh grader, who included a large number of other organs, did not include the stomach. Instead, he drew a long tube-like organ which he labeled "digestive tract" (which may have represented the stomach).

In terms of the total number of major digestive organs and body parts, the third graders are more similar to the kindergarten subjects than to the seventh graders, while the seventh graders differ considerably from both, in that they include all the major organs. With respect to those mentioned by 50% or more, the difference between the seventh graders and the younger subjects is diminished.

Table 25

MAJOR DIGESTIVE ORGANS AND BODY PARTS DEPICTED

	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
Category	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percen
Mouth	5	6	11	55	4	6	10	50	8	9	17	85
Pipe/tube/esophagus	4	2	6	30	9	8	17	85	11	7	18	90
Stomach (total)	9	10	19	95	10	10	20	100	11	9	20	95
a)not enclosed in body outline	4	4	8	40	0	0	0	0	0	0	0	0
separate organ, diagrammatic form	0	0	0	0	2	3	5	25	11	7	18	86
"digestive tract"	0	0	0	0	0	0	0	0	0	1	5	5
b)Body outline included:												
equated with body (label and/or graphic)	4	3	7	35	0	1	1	5	0	0	0	0
"belly button" equated with stomach	0	1	1	5	0	0	0	0	0	0	0	0
equals upper or lower part of body	0	2	2	10	0	0	0	0	0	0	0	0
separate organ within torso	1	0	1	5	8	6	14	70	0	2	2	10
Duodenum	0	0	0	0	0	0	0	0	0	1	1	5
Intestines (small/large not specified	0	0	0	0	2	3	5	25	3	2	5	24
Small intestine	0	0	0	0	0	1	1	5	7	8	15	71
Large intestine	0	0	0	0	1	0	1	5	7	8	15	71
Gall bladder	0	0	0	0	0	0	0	0	0	1	1	5
Liver	0	1	1	5	0	0	0	0	0	5	5	24
Pancreas	0	0	0	0	0	0	0	0	0	3	3	14
Rectum	0	0	0	0	0	0	0	0	1	0	1	5

What is most outstanding in the kindergarten children's drawings is the variety of ways in which the stomach is represented. Two-fifths drew the stomach as a

circle, not enclosed in a body; 35% equated the stomach with the "body" (verbally[1] and/or graphically); for one child, the stomach was represented by the "belly button;" for two, it was either the lower or upper part of the torso. Only one drew the stomach inside an outline of the torso.

The importance of the stomach to the kindergarten children's concepts of the digestive system, as well as their confusion about it, is indicated by the inclusion of other body parts in their depictions of the stomach by some.[2] (Table 26) Two children (10%) drew bones in the stomach--one, bones within the torso extending into the stomach, and another, a bone "that carries the food to the stomach" from the head. Another drew a number of "pipes" in the stomach (the only organ depicted), each for a different food which s/he named. Another drew a mouthlike part in the stomach; and another, who equated the stomach with the torso, enclosed bones, lungs and heart in it.

Table 26
BODY PARTS DEPICTED INSIDE STOMACH--KINDERGARTNERS

Category	Girls (N=10)	Boys (N=10)	Total (N=20)	Percent
Bone inside stomach that carries food from head	0	1	1	5
Pipes in stomach--each for a different food	0	1	1	5
Mouth-like part	0	1	1	5
Bones extending into stomach, within torso	1	0	1	5
Bones, lungs, heart in stomach (equated with torso)	1	0	1	5

[1] That is, what the subject called each organ or body part drawn. The investigator labeled all the kindergarten and most of the third grade drawings while most seventh graders labeled most or all parts of their drawings. The Investigator labeled all parts of a few of the latters' drawings, and some parts of others during the questioning after the drawing had been completed.

[2] It also raises questions about what they mean by "stomach."

b. Other organs and body parts related to the digestive-eliminative-distributive system.

The total number of other related organs and body parts depicted in drawings by one or more subjects increases with age--from 3 (kindergarten) to 7 (third grade) to 14 (seventh grade). (Table 27) The kindergarten subjects drew teeth, throat/neck and the bloodstream carrying food, which they usually called tubes or pipes. The third graders drew, in addition, "hairlike things" in the tube/esophagus, kidneys, a pipe/tube going from the stomach to each of two organs (kidney, intestine). In addition to teeth, throat/neck, kidneys, bloodstream carrying food, and hairlike things in the esophagus, the seventh graders drew "cilia" (sic) in the small intestine, a pipe/tube from the stomach to various organs (intestines, pancreas, liver), salivary glands, bladder, a valve from the liver to the stomach, "digestive tract" (an undefined tube). Of all these additional organs and body parts, only one--the throat/neck--was mentioned by as many as half, and by the kindergarten subjects alone. Only the seventh graders (19%) used arrows to represent the nutrients going into the blood from the intestines (small or large not specified), or specifically from the small and/or large intestine.

The elimination of solid waste from the body is indicated in various ways--by graphic representation only, by labeling and by both graphic representation and labeling. Only one kindergartner represented waste on its way out of the body and told the investigator what it was. One third grader made no graphic representation, but mentioned it during labeling. Aside from the one seventh grader who, as mentioned previously, drew the rectum, 43% of the seventh graders indicated by label, graphically or both, that solid waste was eliminated from the body.

Table 27

OTHER ORGANS AND BODY PARTS RELATED TO THE DIGESTIVE-ELIMINATIVE-DISTRIBUTIVE SYSTEM DEPICTED

	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
Category	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Teeth	0	2	2	10	0	3	3	15	3	2	5	25
Throat/neck	7	3	10	50	3	3	6	30	2	4	6	29
inside body	0	1	1	5	0	0	0	0	0	0	0	0
part of tongue in throat	1	0	1	5	0	0	0	0	0	0	0	0
bones in throat/ neck	1	0	1	5	1	1	2	10	0	0	0	0
Salivary glands	0	0	0	0	0	0	0	0	0	1	1	5
"Hairlike things" in esophagus	0	0	0	0	1	0	1	5	1	0	1	5
"Cilia" in small intestine	0	0	0	0	0	0	0	0	1	1	2	10
Pipe/tube from stomach to kidney	0	0	0	0	1	0	1	5	0	0	0	0
to intestine	0	0	0	0	1	1	2	10	0	1	1	5
to pancreas	0	0	0	0	0	0	0	0	0	1	1	5
to liver	0	0	0	0	0	0	0	0	0	1	1	5
"Digestive system" (=tube going to and from stomach)	0	0	0	0	0	1	1	5	0	0	0	0
"Digestive tract" (=tube)	0	0	0	0	0	0	0	0	0	1	1	5
Kidneys	0	0	0	0	1	0	1	5	0	3	3	14
Bladder	0	0	0	0	0	0	0	0	0	2	2	10
Valve from liver to stomach	0	0	0	0	0	0	0	0	0	1	1	5
Blood vessels carrying nutrients/food	0	1	1	5	1	3	4	20	2	3	5	24
Arrows showing food going into blood	0	0	0	0	0	0	0	0	3	1	4	19
Indication that solid waste leaves body (total)	0	1	1	5	0	1	1	5	5	4	9	43
Label only	0	0	0	0	0	1	1	5	1	1	2	10
Graphic only	0	0	0	0	0	0	0	0	0	1	1	5
Both label and graphic	0	1	1	5	0	0	0	0	4	2	6	29

c. Organs and body parts not related to the digestive-eliminative-distributive system.

More organs and body parts not related to the digestive-eliminative-distributive system were drawn by one or more kindergarten subjects (8) than by third graders (6) or seventh graders (6). (Table 28) The kindergarten subjects drew the belly button, heart, chest, lungs, bones in the body (torso), the bloodstream (not carrying food), the lower part of the body (not named) and "hot pipes that turn food into blood."[1] The third graders included the heart, lungs, bloodstream (without food), "box"/windpipe/trachea, tonsils and brain. The seventh graders drew the heart, lungs, bloodstream (without food), trachea/windpipe, appendix and "flap"/epiglottis. Fewer than 50% of the subjects at any age level included any of the above-mentioned organs. Only one or two kindergartners included any of these. Most frequently depicted by the third graders are the bloodstream and the brain (30% for each) and the heart (25%). The bloodstream (24%), the heart (14%) and the trachea (also 14%) were depicted by the seventh graders.

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1 These may have represented intestines since they resemble them in form.

Table 28
ORGANS AND BODY PARTS NOT RELATED TO THE DIGESTIVE-ELIMINATIVE-DISTRIBUTIVE SYSTEM DEPICTED

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percen
Belly button	2	0	2	10	0	0	0	0	0	0	0	0
Heart	0	2	2	10	3	2	5	25	0	3	3	14
Chest	0	1	1	5	0	0	0	0	0	0	0	0
Lungs	1	0	1	5	2	2	4	20	1	1	2	10
Bones in body (torso)	1	0	1	5	0	0	0	0	0	0	0	0
Bloodstream/veins, etc. (no food)	0	1	1	5	2	4	6	30	1	4	5	24
Lower part of body (unnamed)	0	1	1	5	0	0	0	0	0	0	0	0
"Hot pipes that turn food into blood"	0	1	1	5	0	0	0	0	0	0	0	0
"Box"/trachea/ windpipe	0	0	0	0	2	1	3	15	3	0	3	14
Tonsils	0	0	0	0	1	0	1	5	0	0	0	0
Brain	0	0	0	0	4	2	6	30	0	0	0	0
Appendix	0	0	0	0	0	0	0	0	1	1	2	10
"Flap"/epiglottis	0	0	0	0	0	0	0	0	1	1	2	10

2. Graphic indication of where food goes, indications of movement of food and of changes in it.

Virtually all the subjects depicted food in the body, usually as pieces of different shapes, or lines. (Table 29) The number of places in the body varied, to some extent, with the number of organs and body parts drawn. One kindergarten subject could not depict food in the body because she drew only the throat with two pieces of food alongside.

Graphic indication of move and of changes in the food as a result of digestive processes are related to age, the former more than the latter. No kindergarten subjects, only three-tenths of the third graders and three-quarters of the seventh graders gave some indication of movement, either by lines or arrows. Only

the seventh graders had learned, apparently, that arrows can be used to represent direction.

Changes in the food, indicated by changes in size of the symbols (circles, dots, etc.) and/or the character of the lines representing food, were included by most kindergarten and third grade subjects (65%) and almost all seventh graders. Three kindergartners drew the food whole (a carrot with leaves, a cracker, a hot dog) inside the body, only one showing the change in the food.

Table 29
GRAPHIC INDICATION OF WHERE FOOD GOES, OF MOVEMENT AND OF CHANGES IN FOOD

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent	Girls	Boys	Total	Percent
Where food goes--yes	9	10	19	95	10	10	20	100	11	10	21	100
Where food goes--no	1	0	1	5	0	0	0	0	0	0	0	0
Movement--yes	0	0	0	0	3	3	6	30	8	8	16	76
Movement--no	10	10	20	100	7	7	14	70	3	2	5	24
Changes--yes	8	5	13	65	5	8	13	65	11	9	20	95
Changes--no	2	5	7	35	4	2	6	30	0	1	1	5
Changes--unclear	0	0	0	0	1	0	1	5	0	0	0	0

Some kindergarten (25%) and third grade subjects (20%) drew food in various parts of the body (e.g., arms, legs, brain) to indicate distribution of food to the body. (Table 30) The food was depicted sometimes as pieces, sometimes as heavy, dense lines filling up the body part, sometimes just as lines. Of these, one kindergartner and one third grader drew the food in "tubes" in the legs. Since almost all the seventh graders drew diagrams, and, therefore, no arms, legs, etc., they could not depict food in these parts of the body.

Table 30
FOOD DEPICTED IN VARIOUS PARTS OF THE BODY: KINDERGARTEN AND THIRD GRADE

Category	Kindergarten (N=20)				Third Grade (N=20)			
	Girls	Boys	Total	%	Girls	Boys	Total	%
In arms, legs, feet, brain, etc.	1	3	4	20	2	1	3	15
Tubes containing food in legs	0	1	1	5	1	0	1	5

Although it is surprising, in general, that all the younger children actually drew a picture of the digestive system with only a mental image to guide them, for the most part, it is even more surprising that some were able to depict where the food goes, its movement and changes that take place. The fact that there was usually some resistance to doing so, and that varying amounts of persuasion were necessary to get them to undertake and carry through such a difficult task does not detract from their accomplishment.

3. Body Outline

Some subjects drew a body outline, more or less human and personalized, while others did not. The presence of body outlines was unexpected, in view of the fact that the instructions given for the DPD emphasized food--that is, to draw a picture of what happens to the food in your body--where it goes, how it moves, what it looks like and any changes in it. There was no mention of drawing a body or a person, and the DPD could not have been influenced by the drawing of a person (HFD) since the latter was done during the second session.

The cues used to determine whether or not there was a body outline are as follows:

(1) inclusion of a head with facial features, with or without a recognizable facial expression;

(2) inclusion of arms, legs, feet, and other parts of the body (not just for showing the distribution of food to the body) which transform the drawing into that of a person; and

(3) inclusion of clothing where it does not interfere or cover up the internal body organs, e.g., shoes.

Depiction of the head only, with or without features, was not considered sufficient evidence to be categorized as having a body outline.

More than half the kindergarten (55%) and third grade (75%) subjects drew body outlines, partial or complete. (Table 31) Only two seventh graders (10%), however, drew body outlines. The drawings of most of the latter (85%) look more or less like the diagrams of the digestive system in books. Since more than half of the seventh graders said they had seen pictures or diagrams of the digestive system, the difference between the seventh graders and the younger subjects appears to stem, in part, from the presence or absence of a specific curriculum content.

Table 31

PRESENCE/ABSENCE OF BODY OUTLINE

Category	Kindergarten (N=20)				Third Grade (N=20)				Seventh Grade (N=21)			
	Girls	Boys	Total	%	Girls	Boys	Total	%	Girls	Boys	Total	%
Presence	5	6	11	55	8	7	15	75	0	2	2	10
Absence	5	4	9	45	2	3	5	25	11	8	19	91

Absence of Body Outline. The character of the drawings without body outlines seems to vary with age, in terms of form as well as content (i.e., how much and which parts of the digestive system are included). But there are also variations between individuals within each age group. The kindergarten children's drawings range in content from the simplest--a representation of the throat alone or the throat/esophagus and stomach--to the one slightly more complex one which also includes "hot pipes" (probably representing intestines), the liver and a pipe with blood that goes to the heart. One drawing is limited to the stomach only, within which there are several separate "pipes" for specified foods--peas, pieces of chicken, cucumbers--the size and shape of the pipes suited to the size and shape of the represented food.

With respect to form, those which include neck/esophagus and stomach, and the two that include a head, also have [illegible] form--a more or less oval head, a tube (varying in length) representing the neck or esophagus, and a round stomach (varying in size).

The drawings of the five third graders who did not draw a body outline also vary somewhat both in form and content. Two are similar in that they both include a large tube/esophagus (but varying in both width and length) extending from, in one case, a round mouth and, in the other, a tubelike throat, to a round stomach with "things" or "nerves" (narrow tubes radiating out from the stomach). It is these tubes radiating from the stomach (somewhat like a child's drawing of the sun) which make them look alike. They differ in that one of these also includes large "tonsils," which look like wings, between the throat and the tube/esophagus, and a round "box" attached to the lower end of the tube/esophagus.

The other three drawings are variations on the long tube (esophagus/throat), round stomach form. Two also include intestines--in one case, enclosed winding tubes between the esophagus and stomach, and, in the other, unenclosed narrow winding tubes extending below the stomach. The latter also includes the heart, blood vessels carrying food between the heart and stomach, as well as what looks like other blood vessels.

The drawings without body outline of all but two seventh graders are obvious attempts to replicate the diagrams they had probably seen. These drawings are similar in content in that they all include the major digestive organs. There are individual variations, however, in the other organs (related and unrelated to the digestive system) which are included.

Three of these (all by boys), however, look considerably less like the usual diagram than the others for one or more of the following reasons: (1) the spatial arrangement is distorted; (2) diagonal placement of the drawing; (3) disproportion-

ately large size of both digestive system and non-digestive system organs; (4) strong emphases (heavy lines) on other than the digestive tract; e.g., arrows, food.

Presence of Body Outline. The nature of the body outline appears to be a very individual matter. The kindergarten children's drawings with body outlines vary considerably in the extent to which they resemble drawings of a person with some aspect of digestion included. There are 4 girls and 3 boys whose drawings look most like a person. In these, the head includes facial features with a recognizable facial expression. These drawings may include hair, and either eyelashes or nostrils. The body includes all or most of the following: neck, body/stomach, arms, legs, feet. One or more of the following appear in a very few drawings: fingers, some indication of differentiation of the hands and toes. The drawings that look less like a person (3 boys and 1 girl) vary from those with a head, mouth and teeth as well as a body, arms and legs, to one in which the only claim to personhood is depiction of neck, arms and muscles of the legs with food in them. Thus there is a large range of representation within these eleven drawings.

It is more difficult to describe the third graders' drawings, not only because there are so many (15), but also because they are so varied and individual. There are only two third graders (both girls) who drew actual representations of a person. The first drew a picture of a person with a head, features and facial expression and hair; arms with fingers, body, legs and feet. The other drew two pictures. The first is a profile of a girl with long hair, with all features including eyebrows and nostrils, seated at a table on which there is a plate of food. There is a body, arm with hand and fingers holding a fork pointed at food, and legs with feet. It looks as if she is wearing pants, but, because the digestive organs and food are in the upper part of the body, there is no shirt or blouse. Since it was difficult for her to draw the digestive process in this figure (she did include esophagus and stomach with food in them), she then

drew another partial body outline with many more digestive system and other details.

Eight third graders (2 girls and 6 boys) drew heads, one in profile, with features (5 with pupils of eyes included), some with facial expression and five with hair. Except for the one in profile (which, despite facial features and feet with toes, does not look entirely human, but rather foetus-like) all but two have necks, all have a body, arms and legs, and most have feet. Six have fingers and only one (in addition to the profile one) has toes.

Three third grade girls, who drew quite complete body outlines--neck, body, arms, legs and feet--included only the mouth (but one added hair). Two of these depicted fingers, one also toes. One of these, however, despite the absence of other features, does look human, partly because of the body stance. Two (1 boy and 1 girl)--one in profile--barely meet the requirements for presence of body outline since they included very little. Both depicted heads with mouths, and representations of the torso. One of these also drew legs.

Only two seventh grade boys drew complete head and body outlines. They both depicted necks, arms with fingers, bodies, legs and feet. Only one, however, included facial features--eyes, nose and the stereotyped single-lipped, smiling mouth. The other drew the head in profile with open mouth, and nose, much like the diagrams he had previously seen.

4. Expressive characteristics

As indicated previously, we were interested in exploring cues to the influence of affect as manifested in the DPDs. One possible manifestation of the influence of affect may be the degree of accuracy of the drawing. But there are so many other factors which may influence the accuracy of the drawing that it is impossible to use this feature as a cue. There are other aspects of the drawings, which, like those used in interpreting emotional problems and personality character-

size of organs, and detailed verbal descriptions of processes (which the children themselves wrote when labeling the drawings) appear in the drawings of two or more subjects. The detailed verbal descriptions were given by seven seventh graders,[1] and four drew disproportionately large organs.

Of the 35 subjects whose drawings include one or more of these twelve characteristics, two (disproportionately large organ(s) and overemphasis on blood) appear most frequently (in 23% of the drawings). Heavy lines and detailed verbal descriptions appear almost as frequently (in one-fifth of the drawings). The characteristic that appears most frequently varies at different age levels: at kindergarten level--oral emphasis on food (42%); heavy lines, at the third grade level (42%); and detailed verbal descriptions at the seventh grade level (64%).

The sample is so small that no generalizations can be made from the above figures.

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[1] It is possible that this may be due, in part, to the fact that they did their own labeling, while the investigator did the labeling for all the kindergarten subjects and most of the third graders. She did, however, write whatever the subjects said.

There is another possibility. Gardner (1980), in summarizing possible reasons for the trend toward "literalism" and greater interest in language for expressing ideas in older children, points out the tendency to use verbal notation and made-up symbols in conjunction with their drawings, and that they are often more important than the drawings themselves. It is possible, therefore, that the use of verbal descriptions of processes is part of a developmental trend as well.

Table 32
EXPRESSIVE CHARACTERISTICS

Expressive Characteristics	Kindergarten (N=12)		Third Grade (N=12)		Seventh Grade (N=11)		Total (N=35)	
	Girls	Boys	Girls	Boys	Girls	Boys	Total	Percent
Heavy shading	1	1	0	1	0	2	5	14
Disproportionately large organ(s)	3	0	0	1	3	1	8	23
Overemphasis on blood	0	2	1	3	1	1	8	23
Disorderly, chaotic appearance	2	0	1	0	0	1	4	11
Heavy lines	1	0	1	4	0	1	7	20
Emphasis on waste	0	0	0	1	0	1	2	6
Much erasing	0	0	0	1	0	1	2	6
Oral emphasis (teeth/food)	1	4	0	0	1	0	6	17
Unusually large drawing	0	0	0	1	1	0	2	6
Disproportionately small organs	0	0	1	1	0	0	2	6
Detailed verbal descriptions	0	0	0	0	4	3	7	20
Skewing of placement of tract or organs	0	0	0	0	0	2	2	6

Summary of DPD Findings

The kindergarten children's drawings are usually limited to a depiction of the mouth, throat and stomach and are almost equally divided among those with body outlines and those without. Emphasis on teeth and/or food is found in a quarter of the drawings.

The third grade drawings tend to consist of mouth, esophagus, stomach, usually enclosed in a more of less human-like body outline. Heavy lines are evident in a quarter of the drawings.

The seventh grade drawings tend to include the mouth, esophagus, stomach, both small and large intestines, and some indication, graphic and/or by label, that solid waste is eliminated. The throat, blood vessels carrying nutrients as well as blood vessels without nutrients are depicted in about a quarter of the drawings. Except for two who included an outline of the body, the drawings are in diagrammatic form. There are detailed labels, including description of processes as well as the names of the parts depicted, in about a third of the drawings.

Although some evidence has been given of the individualized character of the drawings, group descriptions do not do them justice. Despite the obvious effort of the seventh graders to reproduce what they had learned and seen in diagrams, many of their drawings are individualized enough to distinguish among them. It is the drawings of the younger children, however, which, while embodying individual concepts of the digestive process, express characteristics peculiar to each individual. The drawing of a body outline by kindergarten and third graders contributes to the general effect of individualization in that many, at both age levels, look human, while a high proportion of kindergarten children's drawings appear to be self-portraits.

There appear to be no sex differences in any aspect of the DPDs.

Comparison of DPDs with Interview Data

If we compare the major digestive organs and body parts depicted in drawings (Table 25) with those mentioned in the interviews (Table 7) by half or more of the subjects (excluding the mouth because it was mentioned early in the interview by the investigator), there is no difference at any age level. Half or more of the kindergarten children mentioned, as well as drew, some representation of the stomach only; of the third graders, both the stomach and esophagus; of the seventh graders, the esophagus, stomach and large and small intestines.

Regarding other organs and body parts related to the digestive-eliminative-distributive system, only at kindergarten level did half or more draw one other body part, the throat/neck (Table 27), while two were mentioned--throat/neck and teeth. (Table 8) No other related organs or body parts were depicted by half or more of third and seventh graders, but the throat/neck and the bloodstream carrying food were mentioned by half or more.

With regard to the elimination of solid waste, while only one kindergartner drew a piece of food on its way out of the body (Table 27), three-fifths mentioned elimination (p. 15). Similarly, only one third grader indicated elimination of waste in the DPD, by label only (Table 27), while three-quarters mentioned it in the interview. The contrast is somewhat less striking for the seventh graders. Not quite half gave some indication in their drawings that waste was eliminated (graphically only, verbally only, or both), one even labeling the rectum (Table 27). While no seventh graders mentioned the rectum specifically in the interviews, all did indicate that waste was eliminated from the body, in non-specific terms.

If we compare the organs and body parts unrelated to the digestive system which were included in the drawings with those mentioned in the interviews, we find that fewer were mentioned at all age levels than were depicted (Table 28)--one mentioned, as compared with eight depicted, by kindergarten subjects; four mentioned by third graders, and three by seventh graders, as compared with six depicted at both age levels.

Many more subjects at all age levels said the food/nutrients were distributed to various parts of the body through the bloodstream (Tables 11 and 13) than included the bloodstream carrying food in their drawings (graphically or by label). (Table 27) Although a higher percentage of seventh graders than younger subjects depicted the bloodstream, the lower figure for seventh graders (24%), compared to the interview figure (91%), may be due to the diagrammatic form of almost all

their drawings. Also a larger proportion of subjects at each age level said that food was distributed to the body (with or without mentioning the route--Table 11) then depicted food in the body (Table 30). The absence of body outline made it impossible for seventh graders to depict food in the body and accounts for the low figure at kindergarten level.

There is no difference between the interview and the DPD with respect to major digestive organs, but more other organs and body parts related to the digestive-eliminative-distributive system are mentioned than depicted by half or more subjects at all age levels. Only with regard to organs and body parts unrelated to the digestive system are there more depicted than mentioned. This is different from the others in that it involves total number of organs or body parts mentioned or depicted rather than mention or depiction by a majority, at each age level. Regarding the four remaining comparisons--elimination, distribution of food to the body, food in the bloodstream and food in parts of the body--more are mentioned by a majority of subjects than are depicted. In the last two, the low figures for seventh graders' DPDs may have been affected by absence of body outlines.

The major difference has to do with elimination. The problem for the kindergarten children may have been how to represent elimination. Most of the third graders drew body outlines, representing the front of the body, making it virtually impossible to depict an exit for solid waste. It was easier for those seventh graders who depicted elimination (usually by leaving an opening at the end of the large intestine) since they drew diagrams, and had apparently learned that they could represent defecation in this way. At the same time, the figure for the DPDs is much lower than for the interviews. Whether or not embarrassment was a factor, for the third and seventh graders, is moot. As indicated previously, the kindergartners showed little embarrassment about elimination in the interviews;

many of the third graders were visibly embarrassed; and the language used by the seventh graders was non-specific and often evasive and distancing. In the DPDs, the only choice for the latter was to depict it or omit it.

IV. REVIEW OF FINDINGS AND DISCUSSION

This section reviews the findings of this study of concepts of digestion, elimination and assimilation of food held by kindergarten, third grade and seventh grade children expressed both verbally and graphically; compares the results with those of other investigators; and discusses their implications and directions for future research. The presence of age level differences in concepts of all aspects of digestive functioning and in the graphic depiction of the digestive system is noteworthy, as is the virtual absence of sex differences. Some age level differences were found in the explanations given, as well as in the cues and sources of information used as the bases for explanations. What is, perhaps, most startling, however, is the variety and nature of the inaccuracies, omissions, misconceptions and confusions held by this sample of middle-class subjects, as expressed both verbally and graphically.

The Interview

Clear increases with age were found in information (not necessarily accurate) about digestive functioning as follows: sequence of food intake to egestion of waste; organs through which the food passes; processes by which food is moved through the gastrointestinal tract; digestive processes; awareness that food is distributed to the body; separation of nutrients from waste and the organ in which this takes place; and the route by which the food is transported. There are also age differences in the reasons given for eating, and an increase, with age, in the

awareness that death results from cessation of eating. Formal education, as well as age, is responsible for the seventh graders' greater knowledge of facts about the digestive system.

The difference between the seventh and third grade subjects is not always as great as might be expected. There are four areas in which the differences are minor: Awareness that food is distributed to the body; that the bloodstream is the route for distribution of digested food to the body; that death would occur as a result of cessation of eating; and in knowledge of the number of digestive organs and/or parts of the body in which digestive processes take place.

The explanations given by the subjects are often based on perceptual cues, including intra-body sensations. Sometimes the questions themselves stimulated such responses, although they did not require them. For example, when asked how they knew they were hungry, instead of citing intra-body sensations, physiological explanations could have been given by seventh graders, but only one tried to do this. The explanations based on perceptual cues, given at all age levels, of why they thought food does not go to specific parts of the body (in itself a misconception), stem from confusion about how the body functions.

At all ages, the children were aware that food (and/or its specific components) was essential for life, health, strength, etc. But their explanations, although increasing in specificity with age, did not usually conform to what is meant by an explanation. The explanations given by kindergartners were, in general, not explanations at all. For example, when asked how they knew they were growing, the response often was, "you grow while you sleep." Even seventh graders tended to use perceptual cues in responding to this question. Although the seventh graders were the only ones who cited physiological facts when asked, for example, how food keeps you alive, helps you grow, etc., they seldom explained the relevant physiological processes. A few tried to explain the role of food in producing

growth in terms of reproduction and multiplication of cells, and only one, how food gives you energy. Here, their inability to understand these complex biochemical processes is not at all surprising. The explanations of how food makes you grow, given by two third graders--that the food turns into blood, skin or bones, although not complete, seem advanced in view of their age and absence of any formal study of the digestive system.

Only two studies, those by Nagy (1953) and Gellert (1962) have investigated children's concepts of the digestive system. Because their studies were more extensive, in terms of number of body systems covered, neither included the degree of detail of knowledge assessed in this study. As a result, our study has added a considerable amount of detailed information to what Nagy and Gellert provided about children's concepts of the organs and functioning of the digestive system, as expressed both verbally and graphically. Comparison of our findings with relevant ones in Nagy's and Gellert's studies yields a broader view of age level differences in children's concepts. It must be emphasized, however, that comparability is limited for several reasons: Gellert's sample consisted of hospitalized children, ranging in age from 4:9 to 16:11, mostly of working-class parentage. Her results were reported according to more gross age groupings; she had three age groups with a range of three, four and five years for the youngest to oldest groups, respectively. Nagy's sample was very large and consisted of English, Hungarian as well as American children. Her results are reported generally in terms of a total national sample.

Gellert made age level comparisons, and found an increase with age with regard to the following: mention of the stomach, esophagus and intestines; digestive processes in the stomach (e.g., dissolving of food, making it smaller); elimination of food from the body (elimination here includes both urination and defecation); mention of food going to other parts of the body. In addition, only

a few of her subjects mentioned blood vessels and that food turns into or enters the blood. A larger percentage of our subjects than Gellert's not only mentioned all of the above but also did so at earlier ages. The idea that food can turn into something else (e.g., fat, bones, blood) was not expressed by Gellert's subjects or ours before age eight and by very few. The subjects in both samples are also similar with regard to the proportion who do not mention elimination at all or elimination by vomiting only.

Nagy's subjects also mentioned the stomach and the esophagus, and were aware that digestion was a function of the stomach and that elimination of food takes place. Since she made no age differentiations, her results are less relevant.

Nagy asked her American sample, "Why do we eat?" She obtained responses very similar to ours--"to live," "to be healthy," "to build our body," "to grow," "to prevent hunger," etc. Because of the manner in which her results are reported, the quantitative findings cannot be compared with those of this study. The similarity in the content of responses to our sample's, however, is worthy of note. Some of Gellert's sample, at all ages, said that food makes them grow.

In her analysis of thinking, Gellert found no evidence of magical thinking. She attributed this to the conditions and methods used in the study, which tended to stimulate realistic responses. In this study, "quasi-animistic" explanations were found more among seventh graders than the younger children. Gellert also found examples of this kind of thinking, but dismissed them because the question which evokes these responses "almost required" them and because "body parts are, in fact, alive" and, therefore, such statements "cannot be equated with spontaneous verbalizations which ascribe separate souls or spirits[1] to non-human phenomena." (p. 394, footnote 18) Although the question asked in this study, "How does food

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[1] Piaget uses the expression "endowed with intentions" (1967, p. 26).

stop hunger?" and "How do you know you're hungry?" might also have provoked this kind of remark, these responses are worth noting because, even if they do not fit the definition of animism, they are evidence of pre-causal thinking.

Gellert also found examples of what appears to be phenomenistic thinking, as we did. She mentions that the "association of events which take place contiguously was sometimes used to explain the function of body parts." (p. 392) Gellert gives several examples of concrete thinking; e.g., "The head contains a camera for your eyes." (p. 396) Using a rather broad interpretation of both Piaget's (1969) and Werner's (1961) definitions of concrete thinking, we find a number of examples at all age levels; e.g., substitutions of description of the subject's experience for an explanation, by kindergarten subjects, explanations based on perceptual cues, including intra-body sensations, at all age levels.

Gellert also mentions instances of inferential thinking. We also found inferences from a principle (e.g., gravity) which does not apply to physiological functioning, inferences from perceptual cues, as well as occasional other inferences.

We found no examples of hypothesizing, even when the subject was asked to guess, and it would have been appropriate to hypothesize. The ability to cite abstract information (physiological, biological) in their explanations is the closest the oldest subjects come to formal thinking.[1]

The lag in the ages at which Gellert's subjects were aware of aspects of functioning of the digestive system, as compared with those in the present study, is probably due to one or more of the differences between the samples--health vs. illness, middle-class vs. working-class background, presence or absence of specific educational experience. In addition, it may be that the children in this study

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[1] It should be noted that this description of types of thinking is based on the explanations given by the subjects. A careful analysis of the thinking processes underlying concepts of physiological functioning, especially with regard to misconceptions, remains to be done.

received more explicit training in health education and nutrition.

Both studies indicate that knowledge of the functioning of the digestive system increases with age. The misconceptions expressed by these two quite different samples of children are similar, as are the types of thinking.

Having reviewed the principal findings of this phase of the study and their relation to previous work, several questions arise:

(1) Why are the seventh graders who studied the digestive system not more outstandingly different in their knowledge of digestive functioning from the third graders who did not study it?

(2) Why is there so little understanding of how the digestive system functions on the part of the seventh graders?

(3) What accounts for the paucity of magical thinking among kindergartners, as well as for the absence of hypothesizing among the seventh graders?

(4) What factors are responsible for the misconceptions, omissions and confusions about the digestive system at all ages? How can these misconceptions throw some light on the nature of thinking about internal body functioning?

(5) To what extent is the structure of the interview responsible for the character of the responses of the subjects?

(6) How do situational factors--unfamiliarity with the interviewer as well as the school context--affect the responses of the subjects?

The Digestive Process Drawing (DPDs)

Age level differences were found with respect to content--an increase with age in the number of major digestive organs and body parts and other organs and body parts related to the digestive system--as well as the presence/absence of a body outline.[1] Perhaps the most unexpected result is that the younger subjects, especially the kindergartners, were able to draw representations of an internal body system--something that they had never seen, touched, or studied.

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[1] Education, as well as age, is a factor in the seventh graders' drawings with respect to content and body outline.

In contrast to this study in which subjects were asked to do a free drawing, both Gellert (1962) and Nagy (1953) provided body outlines and asked the subjects to draw a number of different digestive (and other) organs. Although Tait and Ascher (1955) had sixth graders do a free drawing of the inside of the body, their comments contribute little to our understanding of these drawings. Thus, the other studies in which the subjects were asked to depict digestive organs throw little light on our findings.

Presentation of a body outline results, as Gellert and Nagy have shown, in the representation of the stomach usually as a roundish form within the torso, its location and size varying with circumstances, age, etc. Depiction of the stomach in the drawings of this sample varies because no body outline was presented. Thus, the subjects themselves had the choice of whether to draw a body outline or to draw a diagrammatic representation of the digestive system, and in both, to depict the stomach in any way they chose.

Most of the seventh graders and almost half the kindergartners in this study drew diagrammatic representations, while most of the third graders and about half the kindergartners drew a body outline. The usual diagrammatic representation of the kindergartners, consisting of a tube-like figure (representing the neck or throat) and a more or less circular figure (representing the body/stomach), may be related to their observation of the outside of the body, but the circular figure may also be related to the developmental sequence in drawing.[1]

Many of the kindergartners' drawings with a body outline also include a circular figure as the central section (to which head or neck, arms and legs are attached) which they call the "stomach" or "tummy" when asked what it is. These representations raise questions about what the word "stomach" means to young children.

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[1] As described by Kellogg (Gardner, 1980, p. 41).

Where there is no body outline, it is reasonable to assume that what they call "stomach" actually represents the stomach. When there are bones, neck, heart or other organs in it, its meaning becomes ambiguous. Is the stomach equated in their minds with the body? Or is it a problem of language? When they draw a body outline which often looks like a representation of a person, usually the central section is roundish, and head, neck, arms or legs may extend from it. Since they usually put some representation of food in it, it looks like a representation of the stomach and also, possibly, as if the stomach is equated with the whole torso. When older subjects draw the body outline, the stomach is almost always depicted as a separate organ within the body, (See Table 29)

Fraiberg (1959), who asked children to draw the inside of their bodies during clinical interviews, points out that the "child, until a surprisingly late age, even 8 or 9, imagines his body as a hollow organ, encased in skin. It is all 'stomach' in his imagination, a big hollow tube which is filled with food and emptied of food at other intervals. It is interesting to ask a 6 or 7 year old to draw what he thinks he looks like inside and to see the drawing of an undifferentiated cavern into which the child may, upon reflection, insert a 'heart' in some out-of-the-way place. If you ask the question. 'Where is the stomach?' the child will usually point to the interior of his drawing, indicating all of it. And since the child, at an early age, has discovered that if his skin is scratched or cut, blood will appear, he visualizes the interior of his body as a kind of reservoir in which blood, food and wastes are somehow contained." (pp. 129-130)

During the interview, we asked the subjects to show on themselves where the stomach was, at the same time attempting to find out how much of the abdomen the stomach occupied. Even the kindergartners tended to point to a localized area within the torso.

It is possible that the differences in response are a matter of levels: what is said in the interview as well as the actual localization of the stomach in the abdomen by pointing, are on a more conscious, controlled level. The drawings may reveal their less consciously controlled concept of the stomach, which may be ambiguous in some cases. Fraiberg's clinical interviews would be expected to reveal a concept. the source of which is, at least partly, fantasy--the kind of thing that does not usually emerge in structured interviews.

On a less debatable note, some confusion may result from the language adults use when talking to young children. Parents and even teachers of young children tend to use language which they think likely to be more easily understood by the children, instead of more exact language. Much of what was said by the kindergartners resembles what adults, and, sometimes, older siblings, tell them, or a literal translation of what they have been told.

The presence or absence of a body outline, as well as the nature of the body outline when it is drawn, raises many interesting questions, one of which has to do with the relationship between presence/absence of a body outline and age. We found that all but two seventh graders drew diagrammatic representations;[1] three-quarters of the third graders drew body outlines; and the kindergartners are almost evenly divided in this regard. Since age is confounded with education at the seventh grade level and the kindergartners are almost evenly divided with respect to the presence or absence of a body outline, no conclusions can be drawn from our findings.

Another question stemming from our findings is: Does the presence or absence of a body outline have affective components? Although the absence of a body out-

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[1] In contast, all the sixth graders (mostly male), to whom Tait and Ascher (1955) gave the Inside-of-the-body Test, drew body outlines. They were asked to draw the inside of the body, including all the organs. Perhaps they had not studied the digestive system.

line in the drawings of almost all seventh graders may be due to good visual memory of diagrams of the digestive system they had seen, it also may be the result of their need to detach themselves from the insides of their bodies which, at this stage of development, may be a source of confusion and disturbance.

The body boundary is considered a significant dimension of body image by Fisher and Cleveland (1968), as a barrier to penetration. Since so many third graders drew a body outline, it may be, for them, an expression of the latency stage, symbolizing the covering up or repression of fantasies and feelings.

The almost even division, in the drawings of kindergartners, presents a greater problem of interpretation and one with which we cannot deal without more information. It is significant, however, that a high proportion of their drawings with body outlines are very personalized, that is, they look very much like drawings of a person, some even self-portraits. This suggests an inability to separate themselves as persons from their concepts of the digestive system, and may be related to stage of development. It should be emphasized that all these explanations are highly speculative. Interpretations depend very much on the individual, his/her stage of development and personality characteristics. Both a larger sample and a considerable amount of knowledge about each individual would be necessary for making interpretations.

During the interviews, some subjects expressed their feelings verbally, most often about food (likes and dislikes), learning about the digestive system, how it was taught, and which body systems they might or might not be interested in learning about. Occasionally strong feelings were expressed (usually negative) about the inside of the body in general, or about blood. Because of the infrequency of verbal expression of feeling and because verbal expression of feeling was expected to be on a more conscious level than in drawings, we concentrated on the drawings.

Gorman (1969), in his study of the drawing of the brain, used a small sample of medical experts. He gathered information not only about the physicians' objective knowledge, but also about their life history and personality characteristics. His analysis of inaccuracies and errors in the drawing of the brain, as evidence of "fancies and fears" (p. 251), based on his background data, although not always convincing, is obviously an appropriate way of attaining his aim. Gorman concluded that "the concept, or the image of the brain, becomes closely similar to the image of the person we are." (p. 251)

Since we were primarily interested in exploring children's concepts of the functioning of the digestive system at different age levels, this method was not appropriate to this study. Moreover, we did not concern ourselves with inaccuracies in the drawing of the digestive system because we knew that most of our sample could not be expected to know much about it, and we had no way of distinguishing between lack of knowledge and influence of affect. We concentrated, therefore, on characteristics of the drawings which, in most cases, had little to do with knowledge and were unintentional and probably uncontrollable.

We conjectured that these expressive characteristics might be cues to affect for a number of reasons:

(1) That similar characteristics in drawings of the human figure have been used to indicate presence of emotional problems or pathology, as well as personality trends.

(2) In addition to personalization of the body outlines, these characteristics were the only source of much of the individual variation in the drawings not associated with content.

(3) While we found age level relationships in other aspects of the DPDs, very few of the expressive characteristics revealed any evidence that they might be age-related. This may have been due, in part, to the small size of the sample.

(4) That these characteristics were present in the drawings of a majority of seventh graders and were the major source of individualization.

There are two major objections to the use of such characteristics as cues to affect. As a result of his detailed review of the research and clinical literature, Harris (1963) points out that "the projective hypothesis as it applies to human figure drawings has never been adequately or consistently formulated, and systems for the evaluation of such drawings have, for the most part, been exceedingly loose. Consequently, the assessment of drawings by such methods very often shows modest reliability and low validity." (p. 67)

According to Machover (1949), a strong proponent of the use of human figure drawings as a projective technique, one cannot use individual characteristics of drawings as a check list; one has to look at the drawing as a whole in order to understand aspects of the personality and of the emotional problems of the drawer.

As indicated previously, the characteristics we used as cues to affect were derived directly from this sample of drawings, and are very similar to those used by Machover. Whether or not a more holistic approach to the DPDs is possible depends on further research. Describing these characteristics as possible cues to affect, however, is only a tentative first step toward the ultimate aim--to learn how affect influences concepts of internal body systems and functioning as well as level of thinking with respect to them.

Some questions raised by the DPD findings are: (1) What does "stomach" mean to young children? (2) Do age, stage of development and/or education influence the presence/absence of a body outline in a free drawing of an internal body system? (3) How can expressive characteristics of the drawings, similar to those employed in analyzing drawings of the human figure, be used as cues to the presence of affect?

Practical Applications

Knowledge of the concepts children already have, as well as the nature of their thinking, would be useful for science teachers and those who are responsible for developing curricula for the teaching of body systems and functioning to children. The results of this study, though not definitive because of the small but homogeneous sample, are a first step toward providing such an information base.

Since the seventh graders are the only ones in the sample who had been taught specifically about the digestive system, much of what we shall say is based on analysis of their responses. As the results indicate, the children tend to remember facts, frequently inaccurately. There is also a considerable amount of confusion, resulting in misconceptions of how the digestive system operates. Their understanding of processes is limited. That they are not outstandingly different from the third graders who did not study the digestive system suggests the need for different approaches to the teaching of physiological functioning, as well as in the timing of different approaches to teaching it.

It may be inferred from the seventh graders' responses that, for the most part, the emphasis was on learning of facts and processes, and that the primary teaching mode was presentation of symbolic information--mainly language, but also diagrams, pictures and models. Their formal instruction took place when they were nine- to ten-year olds, a time when thinking is concrete, i.e., they are only capable of thinking in terms of concrete objects and experiences, not in terms of symbolic information and abstractions.

Feelings and attitudes about the body and what happens inside it have their sources in children's experiences and relationships over the years, from infancy on. This is especially true of eating, digestive and eliminative processes. They are an amalgam of all kinds of experiences related to food and eating, internal body sensations, other people's--especially parents'--attitudes, etc. That the

seventh graders responded to the interview questions as if the digestive system had nothing to do with them personally--it was a "subject," something outside of themselves that they had to learn about--raises questions both about the reasons for that objectification and its implications for education.

When the seventh graders were asked whether they liked learning about the digestive system, although more said they did then said they did not, the response of many was mixed or unclear. Some seemed to have said that they liked it because they felt it would be more politic. There were, however, a few who genuinely seemed to have enjoyed it,[1] as well as some who displayed strong negative affect with regard to the inside of the body, verbally or non-verbally.

Byler, Lewis and Totman (1969) asked 5000 children (kindergarten through twelfth grade), among other things, what they would like most to learn about their bodies. From the subjects' questions and other responses, one of their conclusions was that, basically, children want to learn about themselves. There were also age level differences in the body system in which they were most interested. Accordingly, it would seem that the teaching of subject matter pertaining to body functioning to elementary school children should be guided by the following principles:

(1) Children should be encouraged to ask questions and talk about how they think the body functions. In the process, they will find that others have similar ideas, and the teacher will learn what their ideas are.

(2) The content should be geared to children's interests (which have been shown to vary with age), and whichever aspect of body functioning is being studied should be associated with the children's own bodies.

(3) The teacher should stimulate the children to discuss their feelings about the inside of the body, and specifically, the system being studied. All feelings should be accepted by the teacher as normal and used, if possible, to help them understand how the system functions.

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[1] They tended to be among the few who were involved in group "projects" of various kinds, e.g., each member of the group drew a different body system within a large cut-out outline of a body.

(4) The mode of teaching should be as concrete as possible. For example, wherever possible, "experiments" should be carried out by the children themselves (e.g., the effect of enzymes on food), the dissection of animals should be part of the curriculum, or, if that is not possible, the children should be shown and allowed to handle animal organs. Where these or other similar methods are impossible, analogies and metaphors should be used for illustrating and explaining processes.[1]

Perhaps most difficult to achieve is obtaining expression of feelings about the inside of the body and use of these feelings to promote learning, and also the introduction of certain concrete teaching methods. Jones (1968) provides "the rationale for cultivating emotions in the schoolrooms." It is, as he points out, to create conditions "which invite expression of controlled emotions for the purpose of imbuing curricular issues with personal significance. The power of emotion to generate interest and involvement in subject matter which would otherwise find children uninterested and uninvolved lies in their deep personal familiarity--such familiarity being a consequence of emotion having been integral to every phase of personal development from infancy on. The value of emotional involvement in the learning process thus lies in its potential for aiding assimilation of new or remote experiences in idiomatically illuminating ways."[2] (p. 174).

Isaacs (1944) in discussing biological interests of children, includes narrative records of children (aged 5 through 10) dissecting dead rabbits, birds and mice. In this way, they learned from observation and manipulation what the inside of a body is like. Many of the records indicate that these children spontaneously made comparisons of human and animal internal organs, thus relating what they had seen to themselves.

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[1] Miller, both in his book, "The Body in Question" (1978) and his television program on which is book was based (shown on National Education Television's Channel 13 in New York in 1980) used analogies and metaphor to great advantage.

[2] He describes in detail how fifth grade children who were studying the Netsilik Eskimos, many of whose customs were strange, upsetting and repugnant to American children, learned to express and control their feelings, and, with guidance, to use them not only to learn about but also to understand this very different culture.

The use of laboratory methods is less debatable and, therefore, more likely to be used. Because some of our subjects told us, we know that at least one teacher used analogies to explain digestive processes.

The findings also have implications for parents, pediatricians, and clinicians. Many parents are unaware that what they tell their young children about what happens to the food they eat, how it helps you grow, get stronger, etc., is often given literal interpretations by the children and leads to confusion and strange misconceptions. In addition, the inexact language they use for parts of the body, e.g., tummy or stomach for the entire abdomen, is also confusing. Pediatricians may not be aware of the concepts children have at different ages and, as a result, are not only not in a position to give them clarification, but also may add to their confusion. Knowledge of children's concepts may help pediatricians understand better how children feel about their bodies and injuries to them, as well as help them to explain illness and medical procedures. Knowledge of the concepts of normal children, at different ages, would help clinicians distinguish between normal and pathological misconceptions and confusions about the functioning of internal body systems.

Some Suggestions for Future Research

This study of concepts of digestive functioning was undertaken as a first step in a process aimed at finding out (1) whether or not children's ideas about the functioning of internal body systems reveal different patterns of cognitive functioning than do their concepts of external phenomena and processes; and (2) how affect influences and interacts with concepts of internal body functioning. Both of these questions are not only theoretically important, but are also virtually unexplored areas of research.

Although our central focus was not on the thinking that underlies the concepts expressed by our sample, we found some evidence (the paucity of magical thinking, the prevalence of concrete thinking and the absence of hypothesizing or speculating) which suggests that children's thinking about internal body functioning may differ somewhat from their thinking about external phenomena, as described by Piaget.

In order to investigate this, further research is necessary which would focus on the thinking processes underlying the concepts, with particular attention to misconceptions. In order to determine the nature of thinking at different stages of development, and whether or not magical or hypothetical thinking are present, the sample should cover a wider age range, adding, for example, four-year-olds, fourteen- to fifteen-year-olds and adults. Comparison of the results with those on one or more Piagetian measures would clarify similarities and differences with respect to stages of cognitive development, as well as a possible developmental lag with regard to hypothetical reasoning.

The prevalence, in our sample, of explanations based on perceptual cues (both external and intra-body), indicating the presence of concrete thinking at all age levels, suggests the need for investigation of concepts of other body systems which provide fewer relevant perceptual cues than the digestive sytem, and also of the thinking underlying these concepts. Here again, the results, when compared with those on Piagetian measures might provide further insight into the thinking of children and adults.

Some of the findings suggest a need for further information about the effects on concepts of body functioning of formal education in general, and, in particular, different methods of teaching body functioning. The responses of kindergarten and third grade subjects suggest that it would be worthwhile to investigate the influence of informal sources: the kinds of information and explanations given by parents, particularly those from different socioeconomic and ethnic backgrounds;

siblings; and relevant TV programs, all of which may be misleading and confusing at times, particularly to young children, but also informative, at other times, and for older children.

More research is needed on the use of free drawings of internal body systems and their functioning, because they provide another way for the subjects to express what they know and, we believe, how they feel, as follows: A much larger sample of drawings of subjects from diverse backgrounds would make it possible to determine more definitively the developmental changes that take place with regard to the organs and body parts included and their sequence, as well as the movement of food through the system.

Studies are needed to ascertain whether the presence or absence of a body outline is related to age and/or specific body system-related instruction. It would also be important to determine whether the presence/absence of body outline reflects affective components and/or is related to stages of emotional development.

Drawings of an internal body system done by a larger sample, including children of different ages as well as adults, would be useful in determining the presence and frequency, at each age level, of the kinds of expressive characteristics which we have suggested might be cues to affect.

In order to determine the use of drawings of a body system for understanding the influence of affect on ideas about functioning of body systems, methods similar to Gorman's (1969) would be useful. This would involve securing a sample whose knowledge of the functioning of a specific body system was assured and based on firsthand knowledge of the inside of the body (e.g., medical students, surgeons), so that errors and inaccuracies in the drawings of that body system could be taken as possible evidence of how affect influences intellectual functioning. In conjunction with valid measures of emotional problems and personality trends, the

influence of affect on concepts of body functioning could be inferred with greater assurance. In addition, this method could be used for investigating the influence of affect on concepts of a specific body system with a sample of subjects who had just studied this body system. Whether or not these studies would be useful in the development of methods for investigating the influence of affect on concepts of body functioning for children and adults without specialized knowledge is moot, and some modifications would undoubtedly be necessary.

Comparison of each subject's depiction of an internal body system with his/her drawing of a person, with respect to (1) the similarities and dissimilarities of the drawings as a whole; (2) formal characteristics of both drawings (e.g., position on the page, size); and (3) those characteristics present in both drawings which have been used for determining personality trends and emotional problems from the drawings of a person. These, when used in connection with background knowledge from other sources, of personality trends, problems, as well as verbal expressions of feelings about the inside of the body and the specific internal body system under investigation, is another possible method for clarifying how feelings influence concepts of body functioning.

The overriding methodological problem in studies of this sort has to do with how best to stimulate children and adults to tell you what their real concepts are, especially if they think that their ideas are strange or idiosyncratic. This applies more to older children who have studied the body system in question, and adults, who may be ashamed of not knowing and/or whose ideas do not come to consciousness in a formal interview, than to younger ones, who think they know. The major questions raised by this study concern: (1) How structured should the interview be? (2) Can the interview take place outside of the school under circumstances that allow the child to feel more relaxed? (3) Since most older children and adults are unlikely to reveal their fantasies about the workings of the body for someone whom they are meeting for the first time, what sort of design is most likely to overcome the barrier?

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APPENDIX A

The Digestive System Interview

For Kindergarten Subjects

First, I'm going to ask you some questions about eating and what happens to the food you eat.

You may know the answers to some questions and you may not know the answers to the others. But I'm interested in whatever you have to say--even when you're only guessing.

For Third and Seventh Grade Subjects

I'd like to ask you some questions. You may know a lot about some of them, and you may not know much about others. Other people--including grownups--may not know much about some of them either. I'm interested in your ideas and thoughts even if you think you don't know how to answer these questions.

I am the only person who will know what you've said. Neither your teacher nor your parents will be told anything about it. So think of what you're about to do as a kind of game.

First, I'm going to ask you some questions about eating and what happens to the food you eat.

APPENDIX B

WPPSI Vocabulary Test

For Kindergarten Subjects

I want to see how many words you know. Listen carefully and tell me what these words mean. SHOE.....WHAT IS A SHOE?

For each word, investigator says: WHAT IS A_____? Or, WHAT DOES _____MEAN?

If the child's response is not clear, investigator says: TELL ME MORE ABOUT IT, or repeats the question and emphasizes the word.

For homonyns, investigator asks: WHAT ELSE DOES_____MEAN?

WISC Vocabulary Test

For Third and Seventh Grade Subjects

I am going to say some words. Listen carefully and tell me what each word means.

If child points, investigator says: TELL ME IN WORDS WHAT A_____IS.

For homonyns, investigator asks: WHAT ELSE DOES_____MEAN?

If child hears a word incorrectly, investigator says: LISTEN CAREFULLY, WHAT DOES_____MEAN?

If not sure whether child understands meaning of word, investigator says: EXPLAIN WHAT YOU MEAN or TELL ME MORE ABOUT IT.

APPENDIX C

Digestive Process Drawing (DPD)

For Kindergarten, Third Grade and Seventh Grade Subjects

Remember you told me before about what happens to the food you eat. Now I'd like you to draw a picture of what happens to the food in your body.

Show where the food goes, how it moves, what it looks like, and any changes in it.

APPENDIX D

Drawing of a Person

For Kindergarten, Third Grade and Seventh Grade Subjects

Here's a pencil and paper. Would you draw a picture of a person for me? Be sure to make the whole person, not just the head and shoulders.

APPENDIX E

DIGESTIVE SYSTEM INTERVIEW

THIRD GRADE*

Now I'm going to ask you some questions about eating and how your digestive system works.

1. WHAT IS YOUR FAVORITE FOOD?

   What do you like to eat more than anything else?

   What other kinds of food do you like?

2. WHAT KINDS OF FOOD DON'T YOU LIKE?

   Why?

   Do you eat them anyway?

   (If "yes" for any) Why?

   (If "good for you") Why do you think it's good for you?

   What does "good for you" mean?

3. WHEN YOU PUT (NAME OF FOOD) IN YOUR MOUTH, WHAT DO YOU DO?

   (If no answer) Pretend you have _____ in your mouth, what do you do?

   (For bite, chew, swallow) Why do you do that?

   (If answer) How does it do that?

   How do you know that?

   Does anything else happen to the food in your mouth?

   (For each thing mentioned) How does it do that? or What does that?

   (If swallow not mentioned) What happens then? Where does the food go?

4. AFTER YOU SWALLOW THE (FOOD), WHAT HAPPENS TO IT? TELL ME EVERYTHING YOU KNOW ABOUT WHERE IT GOES AND WHAT HAPPENS TO IT.
   (When S finishes, go back and ask the follow-up questions, where necessary.)

   For every part the child mentions, ask the following questions, if necessary:

   How does it get there? or What makes it move?

   How do you know that? or Do you have any way of knowing that?

   Show me on you where it is.

   Does anything happen to the food there? What?

* The interview schedule for third graders, although not exactly the same, is representative of those for kindergarten and seventh grade subjects.

What do you think the food is like when it is in the _____ (density, color)?

How do you know that?

Can you feel the food when it's in your _____?

((f yes) How does it feel?

(If no) Ever? (If no) How about if you've eaten too much or too fast?

Where does it go after that?

IF ELIMINATION NOT MENTIONED

5. DOES ALL THE FOOD STAY IN YOUR BODY?

a. (If yes) Where does it stay?

(If answer) How do you know that?

What is it like when it's in your _____?

When it's in your _____, can you see it?

(If yes) What does it look like?

(If child mentions only one or two places) Can it go anywhere else?,

(If yes) Where?

What does it look like?

(If no other places) Why not?

(If answer) How do you know that?

What happens if you eat more food?

b. (If all the food does not stay in body) Where does it go? How?

How do you know that?

Does all the food you eat go out?

IF ELIMINATION MENTIONED, BUT NOTHING ABOUT FOOD GOING TO OTHER PARTS OF BODY

5. DOES ALL THE FOOD YOU EAT GO OUT?

a. (If no) What happens to the rest of it?

Where does it go?

b. (If food goes to other parts of body) How do you know that?

When it's in your _____, can you see it?

(If yes) What does it look like?

(If child mentions only one or two places) Can it go anywhere else?

(If yes) Where?

What does it look like?

(If no other places) Why not?

How do you know that?

6. WHY DO YOU EAT?

(If for strength) What is "strong"?

How does food make you strong?

(If to live) What is "alive"?

How does food keep you alive?

How do you know that?

(If for growth) How do you know you're growing?

(If for hunger) How do you know you're hungry?

How does it feel?

Where? Show me on you.

7. HOW DOES THE FOOD GET TO (WHEREVER THE CHILD SAYS IT GOES) TO HELP YOU GET STRONG, STAY ALIVE, GROW, STOP BEING HUNGRY, ETC.?

How do you know that?

8. WHAT WOULD HAPPEN IF YOU STOPPED EATING?

(If child says die) What happens when you die?

What does it mean--to die?

What else?

Have you ever seen a dead animal or bird?

(If yes) What was it like?

(If meager response) What can a live _____ do that a dead one can't?

9. YOU'VE TOLD ME A LOT ABOUT WHAT HAPPENS TO FOOD IN YOUR BODY. HOW DID YOU LEARN ABOUT THESE THINGS?

Did your mother or father tell you about any of the things you've been talking about?

(If yes) What?

(If no) Did anybody else? Who? What?

Have you seen any TV programs about what happens to food in the body?

(If yes) Tell me about it. What did you see?

Did you like looking at it?

(If yes) Why? What?

(If no) Why? What?

Have you looked at any books or pictures showing what happens to food in the body?

(If yes) Tell me about it. What did you see (read)?

Did you like looking at it?

(If yes) Why? What?

(If no) Why? What?

For Third and Seventh Grade Subjects Only

10. DO THEY TEACH YOU ANYTHING ABOUT THESE THINGS IN SCHOOL?

(If yes) In what grade (or, how old) were you then?

Did you like learning about your body and how it works?

(If yes) What did you like?

(If no) What did you dislike?

What would you have liked to learn about that you didn't?

11. WOULD YOU LIKE TO KNOW MORE ABOUT WHAT HAPPENS TO FOOD IN YOUR BODY?

(If yes) What?

(If no) Why not?

Is there anything else about your body that you'd like to know?

12. CAN YOU REMEMBER WHAT YOU THOUGHT HAPPENED TO FOOD IN YOUR BODY WHEN YOU WERE YOUNGER?

(If answer) How old were you then?

13. IS THERE ANYTHING ELSE YOU'D LIKE TO TELL ME ABOUT?

Is there anything you forgot to tell me? Anything else that you know or think about--or that worries you about food and what happens to it in your body.